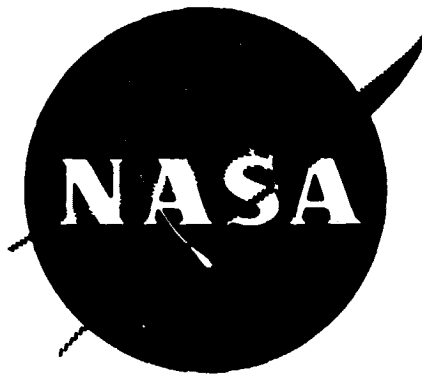


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EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

SYNCHRONOUS ORBIT TESTING OF SEALED NICKEL-CADMIUM CELLS

prepared for

GODDARD SPACE FLIGHT CENTER

CONTRACT S-53742-AG

WQEC/C 81-120A



**WEAPONS QUALITY ENGINEERING CENTER
NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA**

(NASA-CR-168564) RESULTS OF CONTINUOUS
SYNCHRONOUS ORBIT TESTING OF SEALED
NICKEL-CADMIUM CELLS (Naval Weapons Support
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DEPARTMENT OF THE NAVY
NAVAL WEAPONS SUPPORT CENTER
WEAPONS QUALITY ENGINEERING CENTER
CRANE, INDIANA 47522

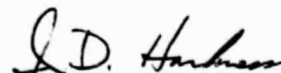
RESULTS OF
CONTINUOUS SYNCHRONOUS ORBIT TESTING
ON

SEALED NICKEL-CADMIUM CELLS

WQEC/C 81-120A

1 JUNE 1981

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Enclosure (1)

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REPORT BRIEF
RESULTS OF
CONTINUOUS SYNCHRONOUS ORBIT TESTING
ON
SEALED NICKEL-CADMIUM CELLS

Ref: (a) NASA Purchase Order S-53742-AG
(b) NASA Work Sheet of Apr 1967

I. TEST ASSIGNMENT BRIEF

A. In compliance with reference (a), this activity began real time synchronous orbit testing on sealed nickel-cadmium cells on 18 July 1967. The evaluation followed the program outline of reference (b).

B. The purpose of this evaluation is to gather performance information concerning sealed nickel-cadmium cells operating under a synchronous orbit regime. Such a regime simulates a space satellite maintaining a position over a fixed point on earth as the earth rotates on its axis and revolves about the sun.

C. This report is a continuation of NAD Crane reports QE/C 71-183, QEEL/C 73-302, and WQEC/C 77-134 and also includes 10 packs that have not been previously reported.

II. SUMMARY OF RESULTS

A. General statements, which would apply to all nickel-cadmium cells, are very difficult to make as each manufacturer's cells have their own characteristics which may vary depending on the operating parameters. It is advisable that each "lot" of cells be subjected to a test program to determine their characteristics. The following statements "generally" apply to a synchronous orbit operation.

1. Voltage degradation, in terms of a decline in capacity available at certain voltage levels, is seen as the main concern in maintaining a spacecraft battery "on-line" during the shadow periods. Initially, approximately 100 percent of the capacity of a battery is available at the 1.10 v/c level; but as the battery approaches 2 years of operation, this percentage can be expected to decrease by 17 to 32 percent at a test temperature of 20°C. A decrease of 5 to 10 percent is expected to the 1.00 v/c level, and only a 2 to 7 percent decrease to the .75 v/c level.

2. The greatest voltage degradation in the end-of-discharge voltages during the shadow periods, occurs from shadow 1 to shadow 2. A reconditioning discharge to a .75 v/c average or lower, prior to each shadow period, will significantly reduce this voltage degradation.

3. Those capacity checks, which are performed on selected cells in a pack in the middle of the shadow periods, provide a reconditioning effect on those cells in that the end-of-discharge voltages are higher than those cells not checked, for approximately 7 to 10 days, following the capacity check. Also, as the cells approach 2 years of operation, this effect becomes noticeable from one shadow period to the next.

4. There is a reconditioning effect, due to the daily discharges the cells receive; as the end-of-discharge voltages the second half of each shadow period are higher than the first half for those cells not capacity checked. This is not true for those cells which are reconditioned prior to their shadow periods.

5. During the sun periods, the cells should be floated at a C/60 (20°C) or C/150 (0° to 15°C) maximum constant current charge rate. If the cells are placed on float, using their shadow period's voltage limit and charge current, they will go into an overcharge condition that will result in lower cell voltages with maximum current and a significant increase in the cells temperature.

6. Cell life at 40°C and -20°C is less than 6 years due to loss of capacity. At 40°C, the cells must be overcharged to maintain an acceptable end-of-discharge voltage during the shadow periods; and at -20°C the cells are essentially undercharged in order to maintain their cell voltages and pressures at an acceptable level.

7. Operation at 0° to 15°C results in less voltage degradation and loss of capacity as compared to 20°C.

B. Specific

1. GE 6.0 ah

a. Two packs (203A and 205A) at 0°C, with 40 and 60 percent DOD, have completed 27 eclipse (shadow) periods without a cell failure. The 40 percent DOD pack delivered 51 percent of rated capacity during its last capacity check, and the 60 percent DOD pack delivered 65 percent.

b. Pack 206A at 0°C and 80 percent DOD was discontinued in the middle of its 22nd shadow period. The pack had two cell failures which occurred during shadows 4 (low discharge voltage) and 11 (shorted).

c. Pack 202A at 25°C and 40 percent DOD was discontinued in the middle of its 22nd shadow period. The pack had one cell failure (shorted) which occurred during shadow 16.

d. The packs (201A and 204B) at 40°C and -20°C were discontinued following shadow periods 11 and 12 respectively. The 40°C pack never delivered the required 40 percent DOD until its last period following three cell failures (low discharge voltage). The -20°C pack was discontinued because of low capacity.

e. Cadmium-cadmium coulometers proved to be effective charge control devices, but they have a shorter life than the cells they are controlling.

f. Figure 1 shows the capacity check results of each shadow period.

2. GE 6.0 ah (IUE)

a. This pack (231A) has completed nine shadow periods in which each period is 25 days duration instead of 42 days. There has been an increase in capacity following shadow 4 due to an apparent sensitivity loss in the controlling auxiliary electrode which has resulted in an increased ampere-hour input. Also, the cells voltage degradation has resulted in a 25 percent minimum loss in capacity to the 1.10 volt/cell average.

3. GE 6.0 ah (GOES D, E, and F)

a. The real-time pack (227D) has completed four shadow periods. Capacity checks, performed prior to each shadow period, have shown no total capacity loss; but the packs voltage degradation has resulted in a 35 percent capacity loss to the 1.10 volt/cell average from shadows 2 to 4.

b. Packs 227E and 227F, the two accelerated packs (1-week sun periods), have completed 12 shadow periods. The packs are capacity checked following every fourth shadow period. Voltage degradation has resulted in approximately a 50 percent decrease in capacity available to the 1.10 volt/cell average and a 15 percent decrease to the 1.00 volt/cell average, when comparing the precycling capacity check with the one following shadow 12. The decrease in total capacity was only 3 percent.

4. GE 12.0 ah (Prototype ATS F & G)

a. Pack 209A at 20°C and 60 percent DOD has completed 24 shadow periods without a cell failure. It delivered 65 percent of rated capacity during its last capacity check.

b. Pack 207A at 0°C and 60 percent DOD and the two 80 percent DOD packs (208A and 210A) at 0°C and 20°C were discontinued in the middle of their 23rd shadow. Each pack had two cell failures due to low discharge voltage. The 0°C pack at 80 percent DOD had the first failure which occurred during shadow 17.

c. Packs 211A and 212A at 40°C and -20°C, respectively, were discontinued because of low capacity, after five and 10 shadow periods, respectively. These packs failed to deliver the required 60 and 80 percent DOD, respectively, during shadow periods 2 and 4.

d. As the life of the 0°C and 20°C packs approached 4 years, their auxiliary electrodes, during the sunlight periods, became "desensitized" to the oxygen produced during charge. This resulted in high cell voltages and pressures for 2 to 7 days at the beginning of each shadow period until the auxiliary electrodes regained their sensitivity. At a life of 6 years, high cell voltages (1.60 to 1.70 volts) were the norm through the entire shadow period.

e. Figure 2 shows the capacity check results of each shadow period.

5. GE 12.0 ah (IUE)

a. This pack (228A) has completed 11 shadow periods without a cell failure.

b. Cell 5, which is capacity checked each shadow, has shown the greatest loss in capacity when compared to other cells which receive capacity checks every other shadow period or every 4th period; however, its voltage degradation is less.

6. GE 40.0 ah (TDRSS)

a. Two packs, one at 0°C (232A) and the other at 15°C (232B) have completed six and two shadow periods, respectively, without a cell failure.

b. The packs are capacity checked prior to every fourth shadow period and are reconditioned prior to the other periods by placing a resistive load across the pack until the pack voltage is .40 volts. As a result of this and the fact that the cells are comparatively new, voltage degradation during the shadow periods is minimal.

7. EP 3.0 ah (SMS and GOES B & C)

a. The first SMS pack (227A) completed one shadow period before its control unit malfunctioned, which forced discharged the cells to negative values. The pack was then discontinued.

b. The other SMS pack (227B) was discontinued in the middle of its 10th shadow period following one cell failure (low discharge voltage) during shadow 6. This pack was previously tested at GSFC for 165 deep-discharge cycles.

c. The GOES B & C pack (227C) has completed 11 shadow periods without a cell failure. Cell 1, which is capacity checked each shadow, has degraded 36 percent in capacity. During the last 8 days of shadow 11, there was a significant drop in the end of charge voltages of four cells. Their average voltage decreased from 1.409 (day 1841) to 1.377 volts (day 1848) with cell 1 decreasing from 1.410 to 1.359 volts.

d. Figure 3 shows the capacity check results of each shadow period for the SMS pack (227B).

8. EP 12.0 ah

a. These packs were discontinued in the middle of their 14th shadow period with one cell failure in the 20°C pack (221A). This was a low discharge voltage failure and occurred during the 11th shadow period.

b. The cell voltages, in each pack, were unbalanced at the end-of-charge during each shadow period as the packs were charged using a voltage limit control.

c. The packs were originally to float at their voltage limits during the sun periods; but due to cell unbalance, the pack temperatures increased causing the charge current to increase while the cell voltages decreased, therefore the packs were placed on a trickle charge (C/60) for these periods. This occurred during first sun period for the 20°C pack (221A), the fifth for the 10°C pack (222A), and the seventh for the 0°C pack (223A).

d. Figure 3 shows the capacity check results of end shadow period for the three packs (221A to 223A).

9. GU 15.0 ah (ATS 6)

a. The engineering cells (Pack 226A) were discontinued in the middle of their 17th shadow period; and the flight cells (Pack 226B) were discontinued in the middle of their 13th shadow period without a cell failure in either pack.

b. Both packs experienced voltage degradation in that when they were discontinued, a minimum of 25 percent of the total average capacity was obtained below 1.00 v/c. During postcycling, only a maximum of 5 percent was available below this level.

c. The flight cells' capacity to 1.00 v/c dropped from 17.18 (shadow 3) to 8.39 ah (shadow 6), as it was cycled during the sun periods prior to shadows 4, 5, and 6. Its capacity increased to 10.49 ah during shadow 7 and was 11.61 ah when it was discontinued.

d. Both packs were to float at their voltage limit during the sun periods; but were placed on a constant current (C/60) float when their voltage limit could not be maintained with a 1.5 ampere charge current.

e. Figure 3 shows the capacity check results of each shadow period.

10. 20.0 ah (GE Standard Cell, EP, SAFT and Yd)

a. GE (Standard Cell) -- This pack (229A) has completed nine shadow periods with no cell failures. Cell 5, which is capacity checked each shadow, has degraded 9.7 percent in capacity from shadows 1 to 9; but its voltage degradation has resulted in a 30.7 percent decrease in capacity available to 1.10 volts and 13.6 percent to 1.00 volts. The other cells, which are not as frequently capacity checked, have shown approximately the same type of results. The cell voltages have been balanced at the end-of-charge with a 3 mv difference between the high and low cells and the mid-shadow (day prior to capacity check, 22.8 hour charge, 1.414 v/c) input is normally 25 to 28 ah.

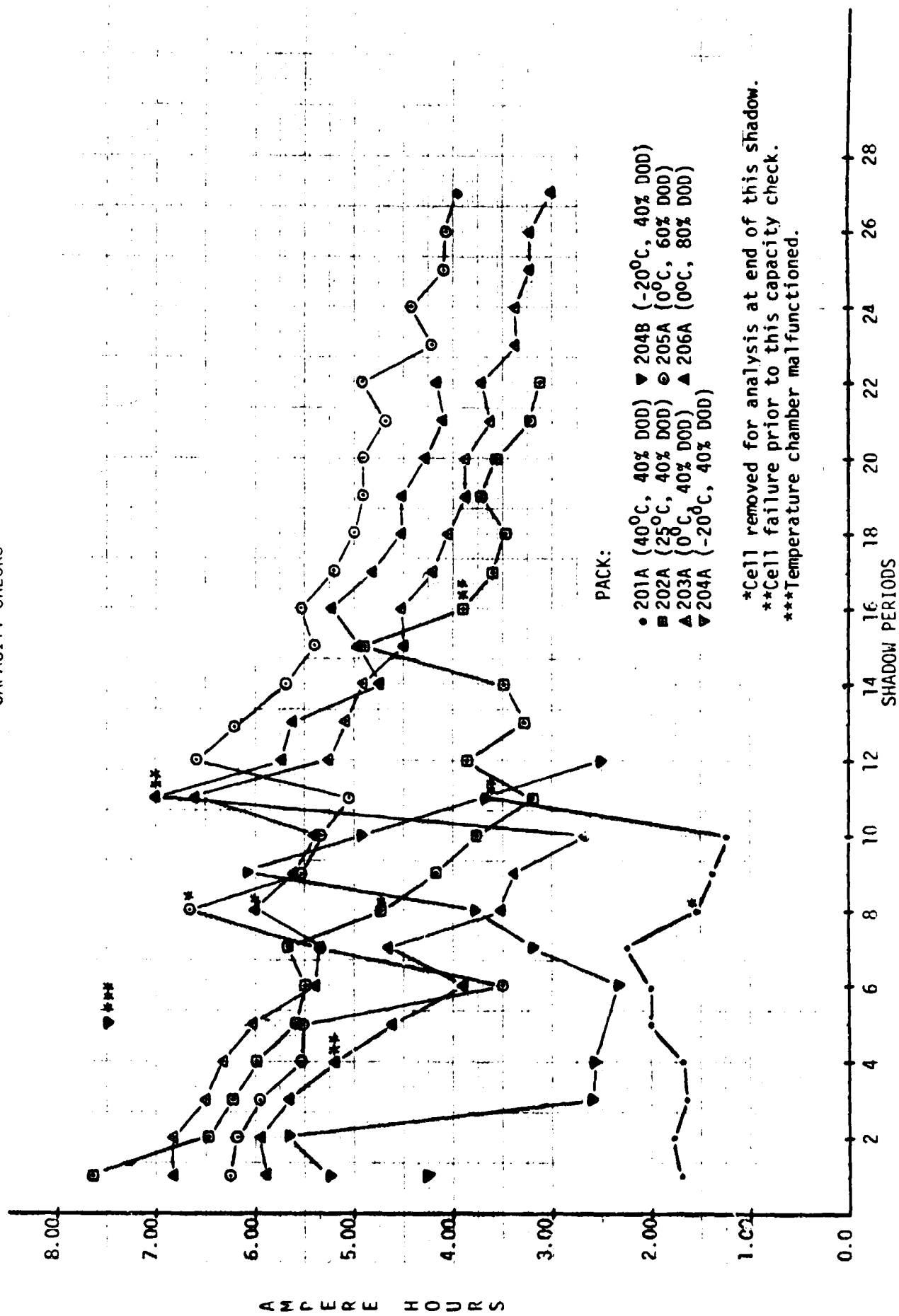
b. EP -- This pack (229C) has completed six shadow periods with no cell failures. Cell 5, which receives a capacity check each shadow, has not had any voltage degradation or capacity loss. The other cells, which are not as frequently capacity checked, have shown a very slight degradation in both capacity and voltage. Typically, the cells have been unbalanced at the end-of-charge (11 mv difference between the high and low cells at mid-shadow during the last shadow period) and the mid-shadow inputs have always been greater than 31 ah.

c. SAFT -- This pack (229B) has completed six shadow periods with no cell failures. Cell 5, which receives a capacity check each shadow, has degraded 5.5 percent in capacity from shadows 1 to 6; but its voltage degradation has resulted in a 26.9 percent decrease in capacity available to 1.10 volts and 12.4 percent to 1.00 volts. The other less frequently checked cells have shown approximately the same type of results. The end-of-charge cell voltages have remained balanced with a 2 to 3 mv difference between the high and low cells, except for approximately 6 days at the start of each of the last three shadow periods as the cells were unbalanced during the preceding sun periods. During the last shadow period, the mid-shadow input was 28.8 ah.

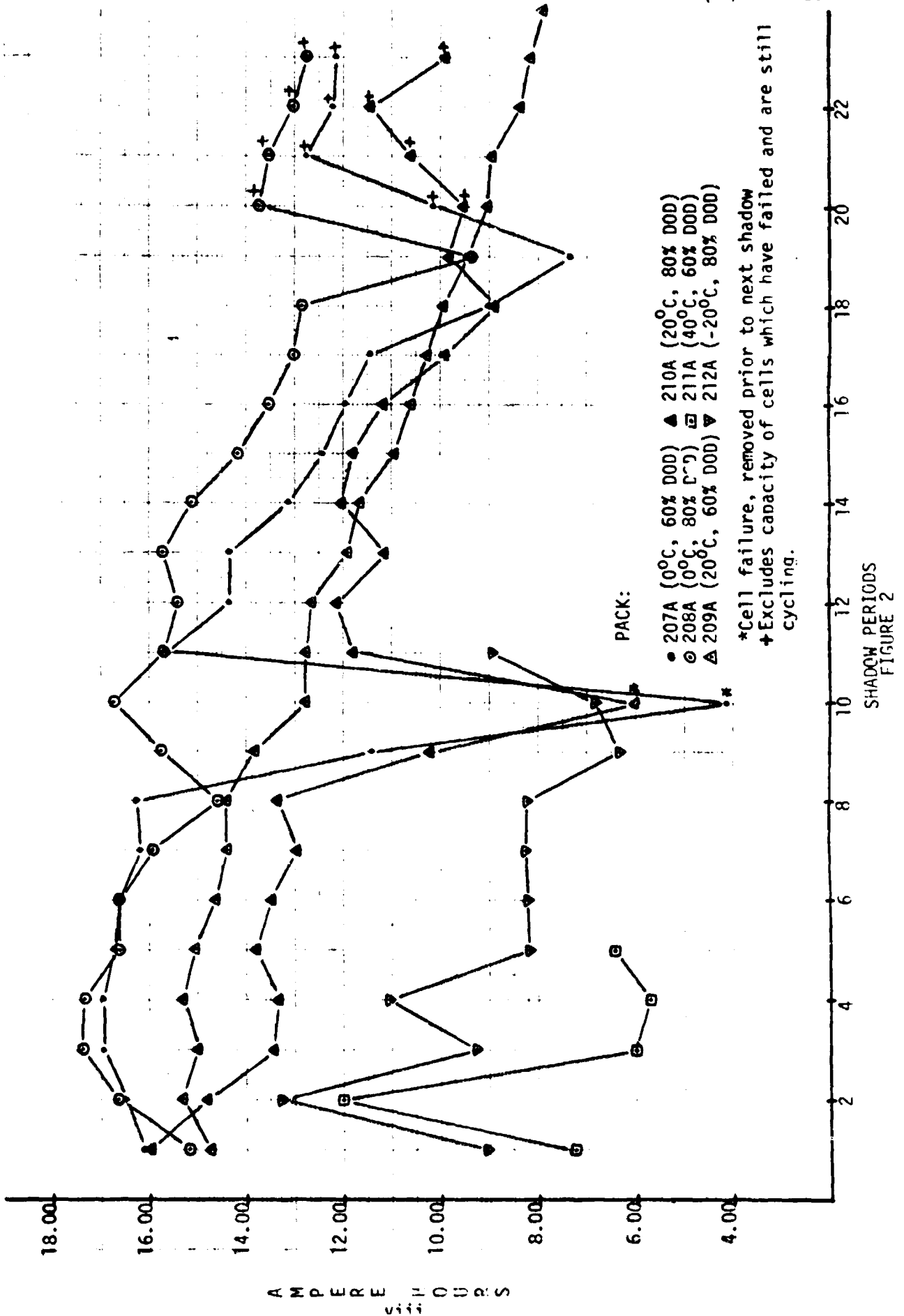
d. Yd -- This pack has completed six shadow periods with one cell failure. Cell 5, which received a capacity check each shadow; shorted following its capacity check (24.76 ah) during shadow 4. Cell 5's voltage degradation, from shadows 1 to 4, had resulted in a 19.4 percent decrease in capacity available to 1.10 volts and a 4.5 percent decrease to 1.00 volts. Typically, the cells have been unbalanced at the end-of-charge (8 mv difference between the high and low cells at mid-shadow during the last shadow period) and the mid-shadow input has been greater than 32 ah the last two shadows.

e. Table I and Figures 4 to 7 show the capacity check results of these packs for each shadow period.

CAPACITY CHECKS

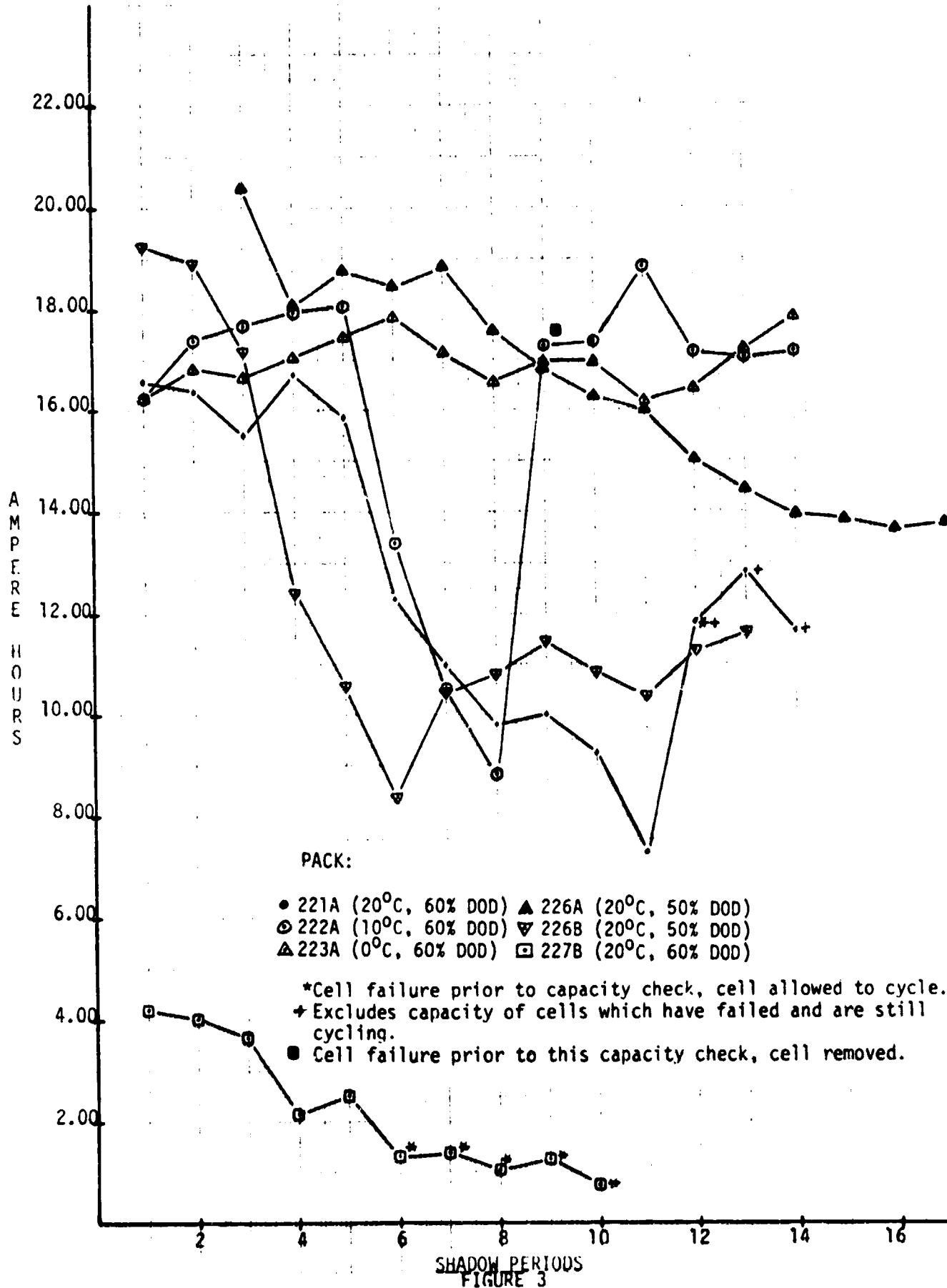


CAPACITY CHECKS



CAPACITY CHECKS

WQEC/C 81-120A



SYNCHRONOUS ORBIT TESTS
AT
NHSC CRANE

CELL TYPE: 20 AH

TEST REGIME: 60% DOD, 20°C

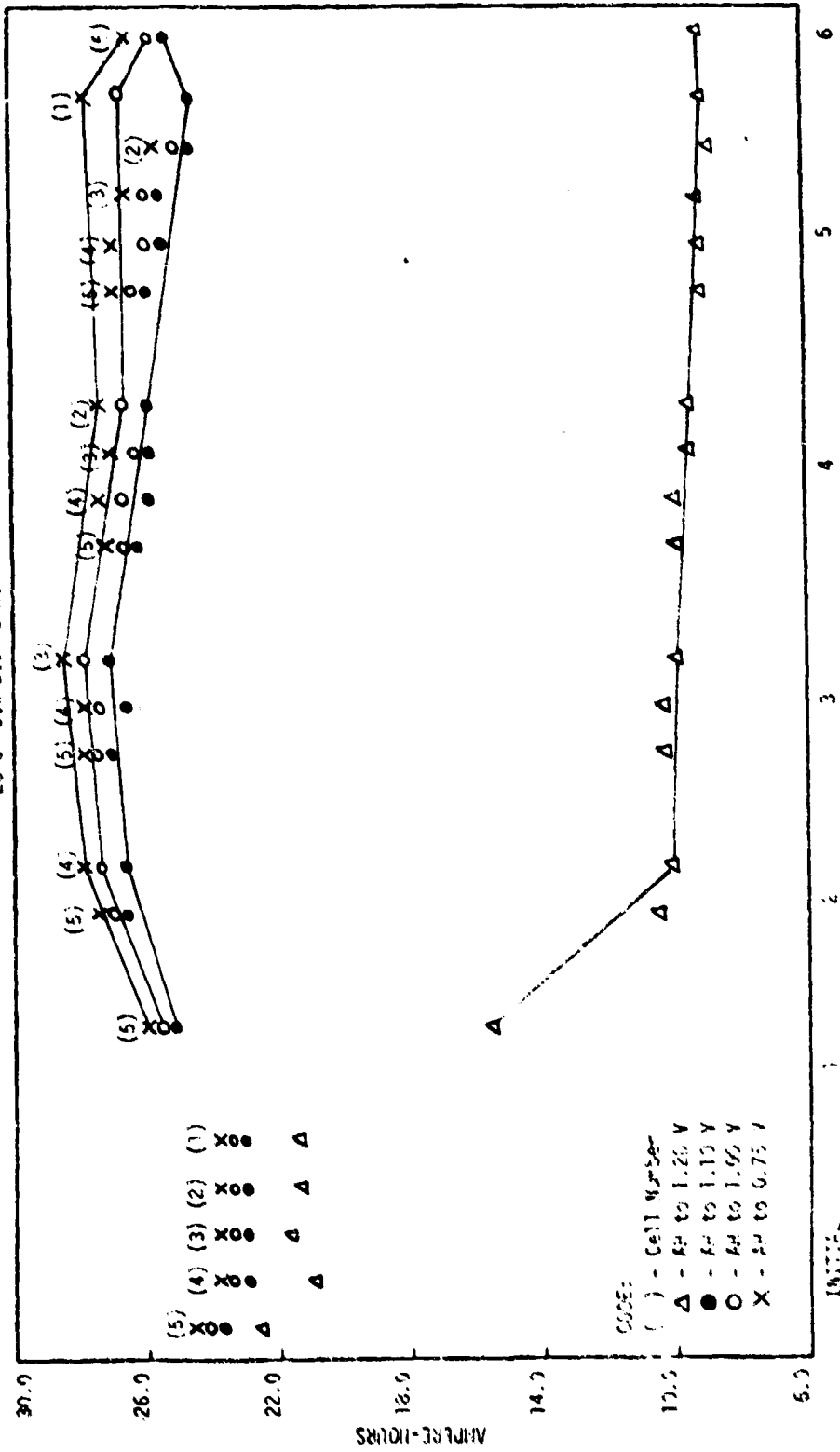
CAPACITY TESTS

SHADOW	CELL	AMPERE-HOURS OUT				
		GE (Standard Cell - Pack 229A)	SAFT (Pack 229B)	EP (Pack 229C)	YD (Pack 229D)	
1	5	24.6	23.6	26.1	24.1	
2	4,5	24.1 22.5	23.7 23.3	28.0 27.6	21.9 24.1	
3	3,4,5	22.6 21.9 21.4	23.7 23.5 23.2	28.6 28.0 28.0	23.8 21.5 24.4	
4	2,3,4,5	22.0 20.9 20.4 20.9	22.2 22.3 22.4 21.6	27.5 27.2 27.5 27.3	23.5 21.8 21.4 24.8*	
5	1,2,3,4,5	21.7 20.7 20.7 20.1 20.7	23.2 22.2 22.6 23.1 22.2	27.9 25.7 26.6 27.1 27.1	24.0 22.7 21.7 22.2	
6	5	21.0	22.3	26.8	23.1	
7	4,5	20.2 20.8				
8	3,4,5	20.7 20.9 21.7				
9	2,3,4,5	21.3 21.6 21.3 22.2				

*Shorted following CX
discharge.

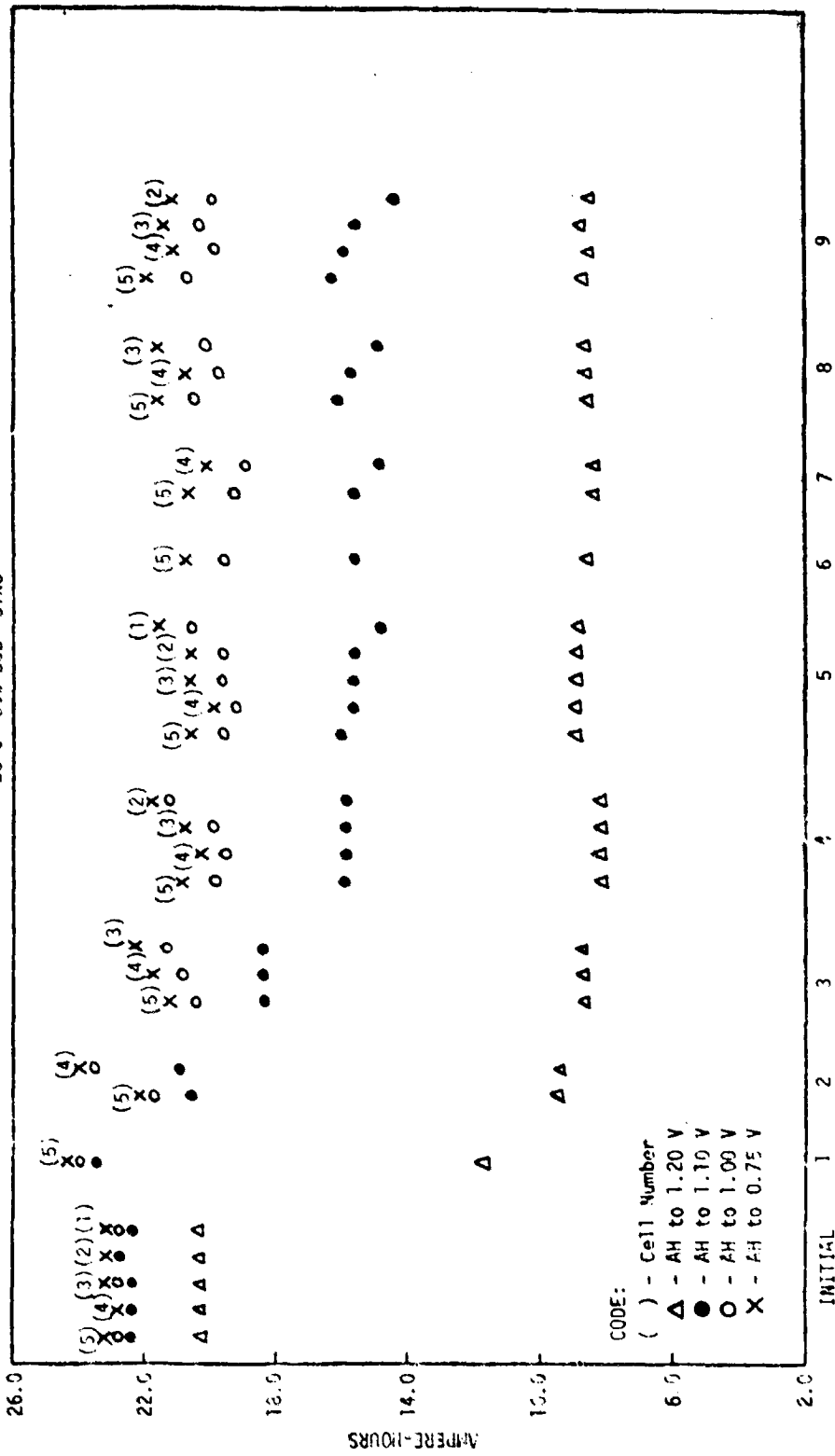
TABLE I

MMSC/OSANE PASS 229C - EP CELLS
20°C 60% SO₂ 50% SWC



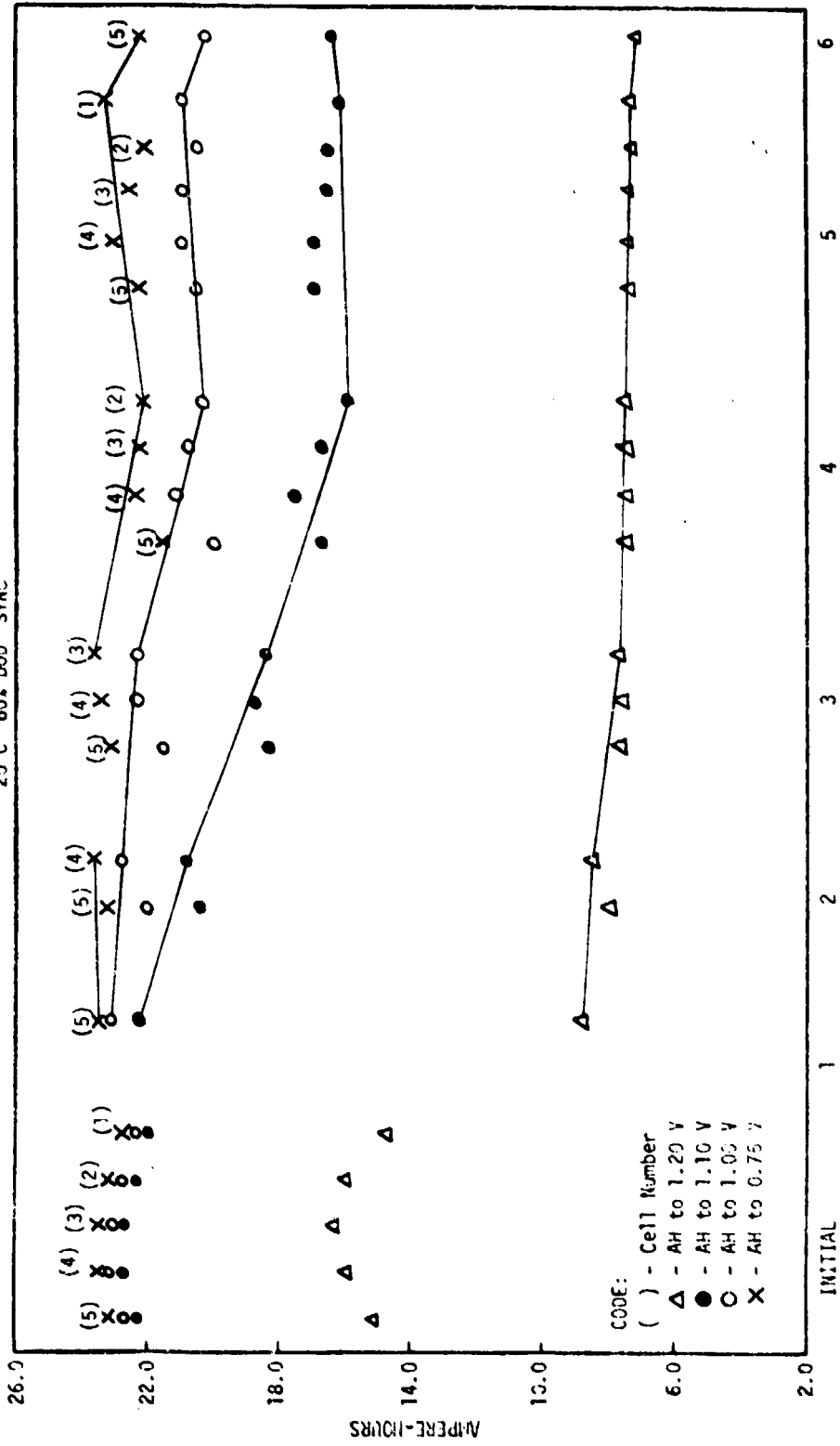
SHADOW PERIOD
(1.414 V/C Voltage Level)
Figure 4

NASA STANDARD 20A1 CELL
 HMSC/CRAIE PACK 229A - GE CELLS
 20°C 60% DOD SYNC

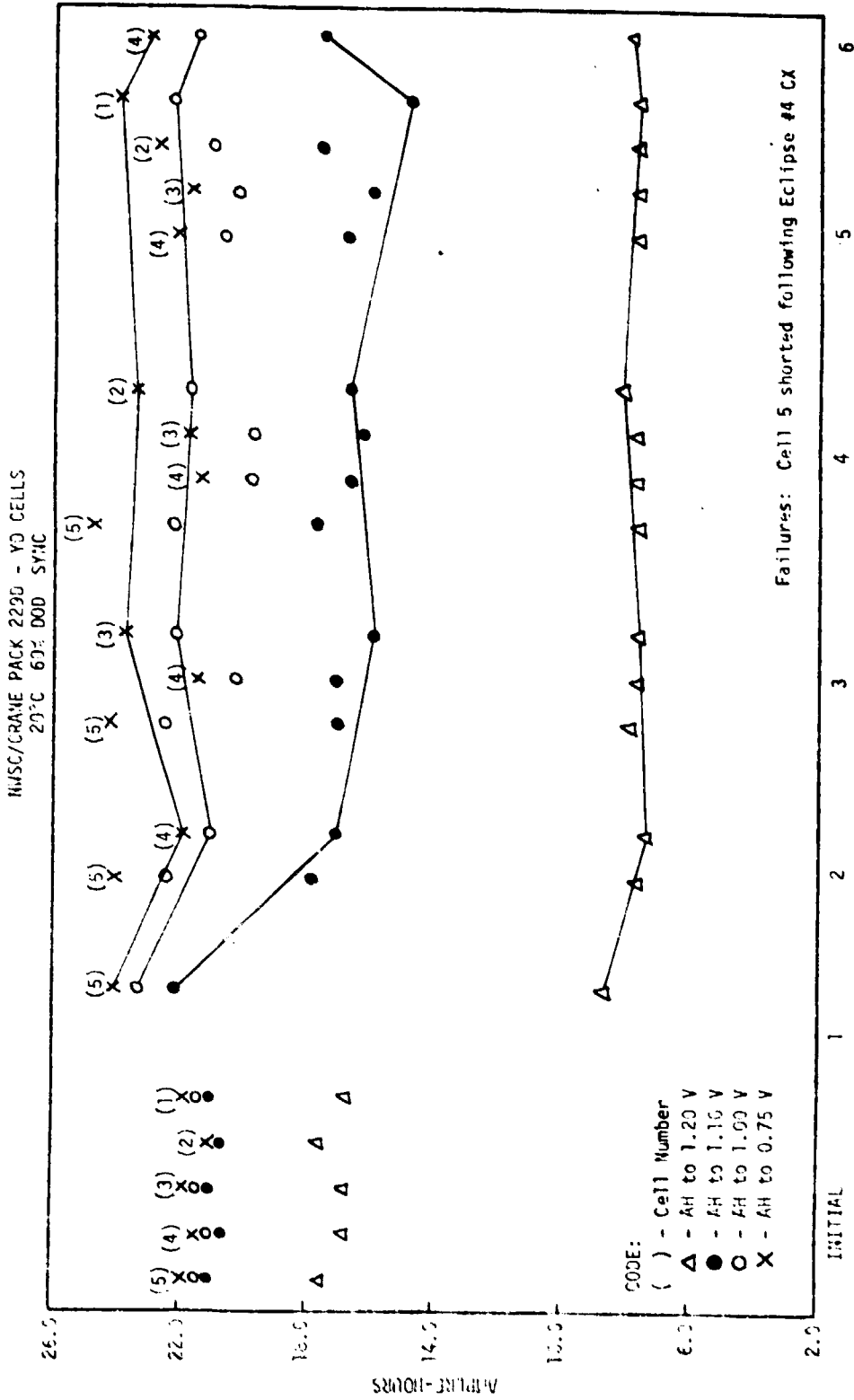


SHADOW PERIOD
 (1.414 V/C Voltage Level)
 Figure 5

NHSC/CRANE PACK 2298 - SAFT CELLS
20°C 60% DOB SYNC



SHADOW PERIOD
(1.414 V/C Voltage Level)
Figure 6



SHADOW PERIOD
(1.414 V/C Voltage Level)
Figure 7

EXPLANATION OF SYMBOLS

1. Special Symbols:

AE: Auxiliary Electrode
ah: ampere-hour
AH: Test Ampere-Hour Rating
Amps: Amperes
ATS: Applications Technology Satellite
DOD: Depth of Discharge
ECL: Eclipse
EOC: End-of-Charge
EOD: End-of-Discharge
EP: Eagle-Picher Industries, Joplin, Missouri
GE: General Electric Company, Gainesville, Florida
GOES: Geostationary Operational Environmental Satellite
GSFC: Goddard Space Flight Center, Greenbelt, Maryland
GU: Gulton Industries, Inc., Metuchen, New Jersey
IUE: International Ultraviolet Explorer
MANF: Manufacturer
ma: milliamperes
mv: millivolts
NASA: National Aeronautics Space Administration
SAFT: SAFT America, Inc., Valdosta, Georgia
SMS: Synchronous Meteorological Satellite
SYNC: Synchronous Orbit
TEMP: Ambient Test Temperature
TDRSS: Tracking Data Relay Satellite System
v/c: Volts per cell
VL: Voltage Limit
YD: Yardney Electric Corporation, Pawcatuck, Connecticut

/

RESULTS OF
CONTINUOUS SYNCHRONOUS ORBIT TESTING
ON
SEALED NICKEL-CADMIUM CELLS

I. INTRODUCTION

A. The real time synchronous orbit tests were first begun on six, 5-cell packs on 18 July 1967. Since then, an additional 26 packs have been placed on test.

B. In a synchronous orbit, the velocity of a satellite and its distance from the earth are adjusted such that one revolution of the satellite matches one rotation of the earth. Such a satellite remains fixed over one location on the earth. The earth's shadow cone changes relative to the satellite's plane of orbit. (See Figure 8) Thus, every 182 days the satellite enters an eclipse season. This season lasts approximately 42 days after which the remaining 140 days are in continuous sunlight. At the beginning of an eclipse season, the satellite first moves through the outer area of the earth's shadow cone. Each day of the eclipse season it progresses through a different section of the shadow cone until it has completely traversed the cone at the end of the season. The satellite's time within the shadow cone thus varies from day to day within the eclipse season beginning with a minimum, progressing to a maximum, and returning to a minimum.

II. TEST CONDITIONS

A. The depth of discharges ranged from 40 to 80 percent and the ambient test temperatures ranged from -20 to 40°C. The majority of the packs tested had ambient temperatures of either 0, 10 or 20°C. Fifteen of the 32 packs contained auxiliary electrode type cells. The cells were rated from 3.0 to 40.0 ampere-hours. The various charge methods used were voltage limit, auxiliary electrode, coulometer, constant current, or a combination of these.

B. To simulate the conditions experienced by the cells aboard a synchronous orbiting satellite, the following 182-day test regime was adopted.

1. Period simulating continuous sunlight (140 days):

a. During this period the cells may be charged at a constant current with or without a voltage limit or on an open-circuit-stand. Some packs started test with a sunlight period whereas others did not.

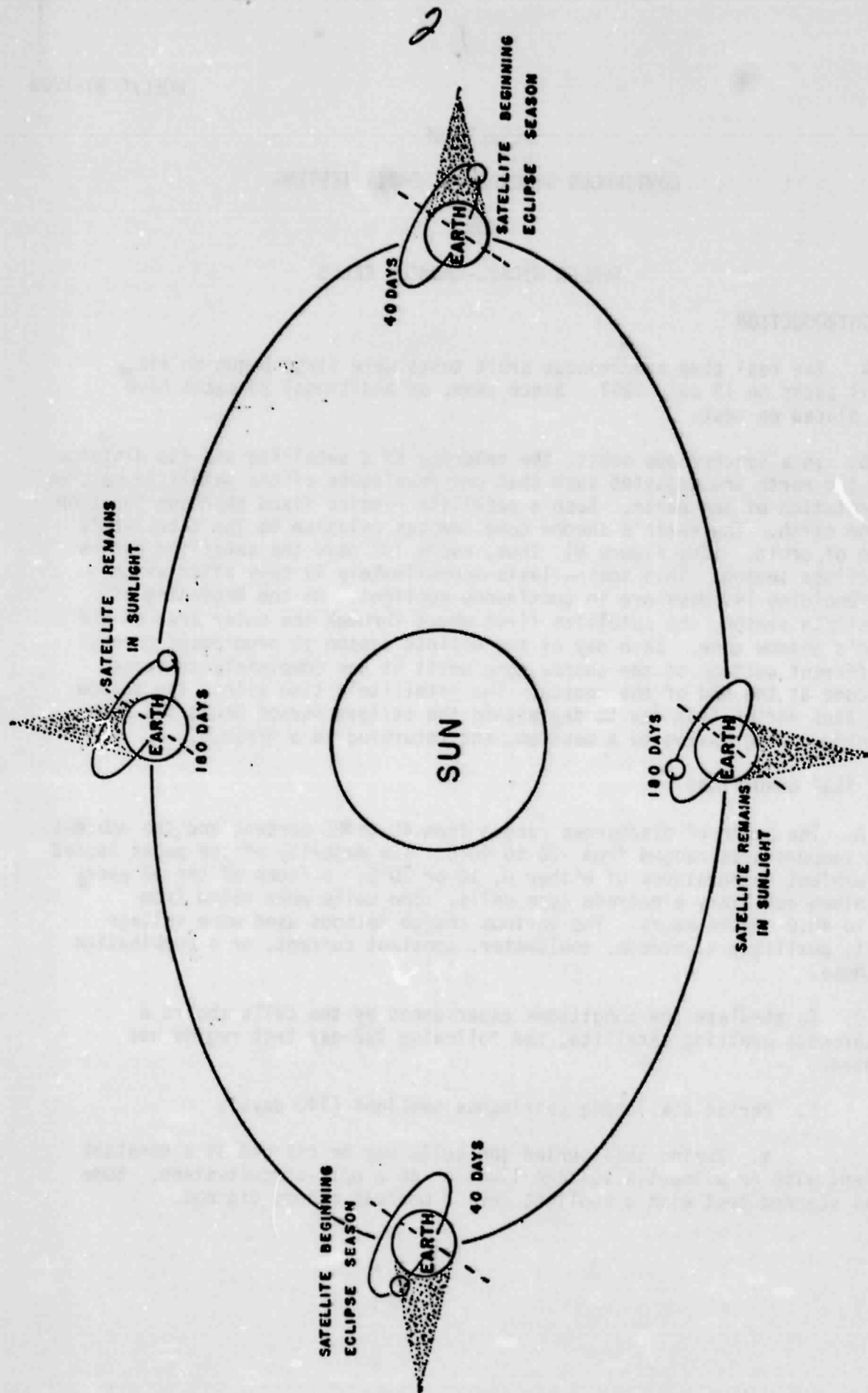


Figure 8
Page 2

2. Period simulating eclipse (shadow) season (42 days):

a. All cells were discharged for 14 minutes the first day of the eclipse season. The discharge time increased by 3 to 5 minutes per day for 20 days to a maximum of 1 hour and 12 minutes. This maximum discharge then occurs once a day for 4 days (20th through 23rd day of eclipse season) with one exception--a capacity check, if scheduled, is always performed the day following the first day the pack was subjected to its maximum discharge.

b. The capacity check was run on the 21st day of the eclipse season. The capacity check consisted of a constant current discharge (rate depending on the depth of discharge) to: a pack voltage based on an average voltage per cell, a low cell voltage, or a combination of the two in which case the first to occur was considered the limiting factor.

c. Following the capacity check, the cells continued the daily discharge of 1 hour and 12 minutes through the 23rd day of the season. From the 24th day to the end of the season, the discharge was shortened by 3 to 5 minutes per day. The last day's discharge was 14 minutes, the same as the first day. The cells then returned to the continuous sunlight period, thus completing the 182-day cycle.

d. Table II identifies the synchronous packs and gives their status as of 1 June 1981. Also, any variations in the preceding 182-day test regime are noted.

III. GENERAL DESCRIPTION

A. Cells:

a. The nickel-cadmium cells on test are of one basic type. They are rectangular with stainless steel containers and covers, both terminals are insulated from the cover by a ceramic seal and protrude through the header as solder-type terminals. Where auxiliary electrodes are present, the terminal is a stainless steel tab welded to the cell header. The separator material is normally nylon (pellon). Any cells differing from this description are separately described as they are encountered in the Test Results, Section V.

B. Charge Control Methods:

a. As a continued effort to improve cells and cell life, various types of charge control methods and devices are being developed. Types of charge control used on the various synchronous packs are as follows:

(1) Constant Current (CC) -- pack is charged at a constant current.

(2) Voltage Limit (VL) -- pack is charged at a constant current to a average voltage per cell, then the current tapers while still maintaining the pack at the voltage limit.

(3) Coulometer (CLM) -- the coulometer is a device which measures the amount of electrical charge (coulombs or ampere-hours) passed through it. It accomplishes this by means of an electrochemical reaction which is directly proportional to the magnitude of the current and the time for which it is passed. Therefore, the cells are constant current charged until limited by their coulometer to a trickle charge or to open-circuit.

(4) Auxiliary Electrode (AE) -- the packs are constant current charged until a preset (trip) voltage is reached by either a specific controlling electrode, or any one of the auxiliary electrodes in the pack. The reaction of oxygen (produced on charge) with the active material of the auxiliary electrode produces a voltage in direct proportion to the oxygen pressure and, consequently the amount of charge to the auxiliary electrode. After reaching the trip voltage of the auxiliary electrode, the charge current is reduced to a trickle charge or the pack may go on open-circuit.

(5) Auxiliary Electrode and Voltage Limit (AE/VL) -- packs are constant current charged with a voltage limit until an auxiliary electrode voltage reaches its trip voltage, then the current may be reduced to a trickle charge value. Also, as an example, it may be specified that the charge current begin to taper downward when the auxiliary electrode reaches 150 millivolts and as the electrode reaches or exceeds 180 millivolts, the charge current would be at its minimum value. The auxiliary electrode control then is considered as having a bandwidth of 30 millivolts.

IV. EXPLANATION OF DATA PRESENTED

A. The test results are shown graphically in Figures 9 through 368. The graphs pertaining to each synchronous (Sync) pack immediately follows the discussion of that pack. Also, the information from which the graphs were plotted is contained in Crane Report WQEC/C 81-120B which is available upon request.

1. The first graphs for each pack show the precycling and eclipse season capacity checks. Postcycling capacity checks are also included when applicable. Precycling and postcycling capacity checks were performed at the eclipse ambient test temperature, following the same type charge as the pack receives during the eclipse season.

2. The other graphs show the performance of the pack through its eclipse seasons.

NOTE: (a) In all the computer printouts, if two characters share the same location on the page, only one will be printed. Thus if the auxiliary electrode voltage occupies the same location as the end of discharge voltage, on the same day, only one symbol is implied rather than appear as a strikeover.

(b) The packs are controlled and monitored by a computerized data acquisition system. The system "looks at" each pack every 2.4 minutes and data may be recorded at this time or at various 2.4 minute intervals depending on the test requirements. If the pack is being controlled on an auxiliary electrode or coulometer trip voltage or is being capacity checked, it may not trip out at the exact limiting voltage since the system monitors and controls these parameters in 2.4 minute intervals.

3. Capacity check data listed under the cell designations may either be voltages or ampere-hours out, for that cell, at the end of discharge. When a value is listed in the ampere-hours (ah) out column, for that capacity check, the values for the cells are end of discharge voltages. When nothing is listed under the ah out column, then the cell values are actual ampere-hours out for that cell at the end of discharge; but if the pack was being discontinued, the ah column value would indicate the capacity obtained using the normal capacity check criterial.

4. The start-of-float data presented are those values obtained 24 hours following the end of the shadow period if the charge conditions for float were not the same as those at the end of the shadow period.

5. The discussion of each pack will only pertain to significant changes or trends observed, cell failures and test parameter changes. No attempt will be made to expound on each graph since, in most cases, they are self-explanatory. The eclipse (shadow) seasons will be discussed first, then the pack's performance during the sunlight periods will follow. The term "mid-shadow" refers to the middle of the shadow period (day 20) the first day when the pack is at maximum percent depth-of-discharge which is followed by a 22.8-hour charge period..

6. Analysis (visual) comments on cells which have failed or were discontinued will be at the end of each pack's discussion.

TABLE II
SUMMARY OF SYNCHRONOUS ORBIT PACKS

PACK NUMBER	MFR	DEPTH	TEMP	TYPE	AH	SHADOW PERIOD COMPLETED	DAYS* RUN	STATUS	PROJECT	CELLS (FAILED/TOTAL)
201A	GE	40%	40°	NICD	6	#11	1948	Completed 11-19-72	Sync. Orbit	3/5
202A	GE	40%	25°	NICD	6	#21.5	4089	Discontinued 10-27-78	Sync. Orbit	1/5
203A	GE	40%	0°	NICD	6	#27	5034	In sunlight #28	Sync. Orbit	0/5
204A	GE	40%	-20°	NICD	6	#1 (failed 2nd day of #2)	200	Completed 2-5-68	Sync. Orbit	1/5
204B	GE	40%	-20°	NICD	6	#12	2198	Discontinued 8-28-74	Sync. Orbit	0/5
205A	GE	60%	0°	NICD	6	#27	5034	In sunlight #28	Sync. Orbit	0/5
206A	GE	80%	0°	NICD	6	#21.5	4101	Discontinued 11-8-78	Sync. Orbit	2/5
207A	GE	60%	0°	NICD	12	#22.5	4193	Discontinued 10-22-80	ATS F&G	2/5
208A	GE	80%	0°	NICD	12	#22.5	4193	Discontinued 10-22-80	ATS F&G	2/5
209A	GE	60%	20°	NICD	12	#24	4417	In sunlight #24	ATS F&G	0/5
210A	GE	80%	20°	NICD	12	#22.5	4193	Discontinued 10-22-80	ATS F&G	2/5
211A	GE	60%	40°	NICD	12	#5	793	Completed 5-26-71	ATS F&G	5/5
212A	GE	80%	-20°	NICD	12	#11	1962	Discontinued 8-28-74	ATS F&G	4/5
212A	GE	60%	20°	NICD	12	#13.5	2654	Discontinued 10-27-78	Sync. Orbit	0/5
221A	EP	60%	20°	NICD	12	#13.5	2654	Discontinued 10-27-78	Sync. Orbit	0/5
222A	EP	60%	10°	NICD	12	#13.5	2666	Discontinued 11-8-78	Sync. Orbit	0/5
223A	EP	60%	0°	NICD	12	#13.5(1)	2717	Discontinued 10-22-80	ATS 6	0/5
226A	GU	50%	20°	NICD	15	#16.5(1)	2355	Discontinued 10-22-80	ATS 6	0/5
226B	GU	50%	20°	NICD	15	#12.5	59	Discontinued 2-6-74	SMS	0/5
227A	EP	60%	20°	NICD	3	#1(5)	1780	Discontinued 4-26-79	SMS	3/5
227B	EP	60%	20°	NICD	3	#10.5(6)	1869	In sunlight #11	GOES B & C	0/5
227C	EP	60%	20°	NICD	3	#11	704	In sunlight #5	GOES D,E & F	0/7
227D	GE	52%	15°	NICD	6	#4(7)	704	In shadow #13	GOES D,E & F	0/5
227E	GE	52%	15°	NICD	6	#12(3)(4)	704	In shadow #13	GOES D,E & F	0/5
227F	GE	52%	15°	NICD	6	#12(3)(4)	704	In shadow #13	GOES D,E & F	0/5
228A	GE	80%	20°	NICD	12	#11	1866	In sunlight #11	IUE	0/5
229A	GE	60%	20°	NICD	20	#9	1446	In sunlight #9	Standard Cell	0/5
229B	SAFT	60%	20°	NICD	20	#6	977	In sunlight #6		0/5
229C	EP	60%	20°	NICD	20	#6	977	In sunlight #6		0/5
229D	YD	60%	20°	NICD	20	#6	977	In sunlight #6		0/5
231A	GE	80%	10°	NICD	6	#9(2)	1382	In sunlight #9	IUE	3/10
232A	GE	50%	0°	NICD	40	#6(7)	907	In sunlight #6	TDRSS	1/5
232B	GE	50%	15°	NICD	40	#3(7)	464	In sunlight #3	TDRS	0/5

*--Number of calendar days as of 1 June 1981

- (1) includes 2 completed at GSFC
- (2) shadow period is 25 days
- (3) capacity checked following each 4th shadow period
- (4) accelerated orbit, 1 week sunlight period
- (5) hardware malfunction
- (6) previously tested at GSFC, 165 deep-discharge cycles
- (7) capacity checked prior to each shadow period

V. TEST RESULTS

A. EP 3.0 ah (SMS and GOES B & C)

1. Pack 227A, 5-cells, (SMS)

a. Cell information:

(1) The cells were purchased by Philco-Ford under Contract NAS-5-21575 for NASA, GSFC. The cells were identified with the manufactures serial numbers and were from EP lot #4. The cells were fitted with pressure transducers prior to testing. Initial evaluation test results and detailed cell descriptions are contained in the NAD Crane Report QEEL/C 73-380 of 29 October 1973. This pack was tested at 20°C, with a depth of discharge of 60 percent. The pack was discontinued following its first shadow period as the cells were reversed due to a hardware malfunction. Results of this pack were reported in the Crane Report WQEC/C 77-134 of 9 June 1977.

2. Pack 227B, 5-cells (SMS)

a. Cell information:

(1) The cells were manufactured under NASA prime contract NAS-5-21575, to Philco-Fords' specification number SP-212064C. These cells were identified with the manufacturers serial numbers and were from EP lot #6. The cells were previously tested at GSFC for 165 cycles (60 or 100% DOD, and a temperature range of 0 to 35°C) as per TP 761.2-73-03. Other cells from this cell lot are in Philco-Ford Battery S/N's 1005 and 1006. The cells were fitted with pressure transducers prior to testing. Results of the first 4 eclipse seasons were reported in the Crane Report WQEC/C 77-134 of 9 June 1977.

b. Parameters:

Depth of Discharge (%)	60	Discharge Current (amps)	1.5
Charge Control	CC	Temperature (C°)	20
Charge Current (amps)*	.15	Float Current (amps)	.075

*Increased to .20 amps during shadow period 7.

c. Capacity Checks: (Discharge to .75 volts any cell)

	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	ah out
Preshadow*	1.050	.848	.982	1.162	.961	3.98
Shadow 1	.679	.414	.605	.441	.581	4.20
Shadow 2	.767	.590	.789	.474	.632	4.06
Shadow 3	.852	.684	.819	.573	.441	3.65
Shadow 4	1.068	.924	1.018	1.168	.445	2.18
Shadow 5 (Figure 9)	1.006	.723	.974	1.088	.476	2.52
Shadow 6 (Figure 10)	1.132	.464**	1.022	1.191	.818	1.31
Shadow 7 (Figure 11)	1.146	.369	.902	1.209	.766	1.40
Shadow 8 (Figure 12)	1.128	.325	.949	1.201	.886	1.08
Shadow 9 (Figure 13)	1.089	.354	.944	1.203	.885	1.28
Shadow 10 (Figure 14)	(3.21)	(.78)	(1.50)	(3.06)	(1.17)	
Post Cycling (Figure 15)	(4.01)	(1.75)	(2.99)	(3.31)	(2.36)	

*Preshadow--capacity check (5.0 volts/pack) followed 14 life cycles at 25°C and 60% DOD.

**--Failed, 26th day of shadow 6; but allowed to continue cycling.

d. Test results during the Shadow Periods: (Figures 16 to 19)

(1) Cell 2 failed (below .75 volts during discharge) during shadow 6 (day 1096). It was allowed to remain on test; but the daily discharge was terminated when the average voltage of the pack decreased below 1.000 V/C. An attempt to improve the packs capacity was initiated, on day 1270 of shadow 7, by increasing the charge current from .15 to .20 amperes. Cell 2 then failed again on day 1277 of shadow 7. If cell 2 had not been the limiting factor during discharge, cells 5 and 3 would have failed during shadows 6 and 7 respectively.

(2) End of Discharge Voltages: There was a decline in the EOD voltages, following shadow 2, due to cell 5. The high EOD voltages, before the capacity check, had declined from 1.215 volts (shadow 1) to 1.179 volts (shadow 5). The high EOD voltages, following the capacity check, also declined from 1.249 volts to 1.199 volts for shadows 1 and 5, respectively. Cell 2 became the limiting cell during discharge in shadow 6, and the discharge was always terminated prior to the time limit of 1.2 hours (1.80 ah) in the middle portion of this shadow and shadows 7 through 10.

(3) End of Charge Voltages: The average mid-shadow EOC voltages decreased from 1.423 volts (shadow 1) to 1.392 volts (shadow 5). An increase of 15 millivolts in these voltages was obtained when the charge current was increased to .20 amperes (shadow 7).

(4) Pressures at End of Discharge and Charge: There has been no change in the cyclic pressure trend throughout the shadow periods. The end of charge pressures, for the 5 cells, ranged from 0 to 21 PSIA and the end of discharge pressures ranged from 1 to 2 PSIA less than those at the end of charge.

(5) The pack was discontinued in the middle of shadow 10 in which each cell was discharged to .500 volts.

(6) Post Cycling: Capacities ranged from 1.75 (cell 2) to 4.01 (cell 1) ampere-hours following a .30 ampere charge for 24 hours at 20°C.

(7) One cell was sent to GSFC and another to EP for analysis. The remaining cells were disposed of.

e. Performance during sun period: This pack completed 10 periods, in which it had an abbreviated initial period (2 months), prior to the start of its first shadow period. Following is a listing of the high, average, and low cell voltages at the start and end of each sun period. The pressure range, for the five cells, was 0-16 PSIA during these periods.

Sun Periods

Voltages***	1		2		3		4		5	
	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>
High	1.438(1)	1.416(2)	1.400(1,5)	1.389(2)	1.396(1,3)	1.372(2)	1.398(1,4)	1.388(1)	1.395(1)	1.395(2)
Average	1.431	1.403	1.397	1.367	1.394	1.354	1.391	1.378	1.361	1.391
Low	1.409(4)	1.368(4)	1.392(4)	1.329(4)	1.392(4,5)	1.311(4)	1.384(5)	1.365(4)	1.321(2)	1.386(4)
Voltages	6		7		8		9		10	
	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>	<u>Start</u>	<u>End</u>
High	1.405(1)	1.382(2)	1.390(1)	1.389(3)	1.388(1)	1.392(3)	1.386(1)	1.395(3)	1.367(4)	1.387(1)
Average	1.385	1.372	1.368	1.369	1.347	1.374	1.348	1.379	1.345	1.374
Low	1.369(5)	1.347(4)	1.336(5)	1.348(4,5)	1.311(5)	1.363(2)	1.316(3)	1.363(4)	1.316(1)	1.359(4)

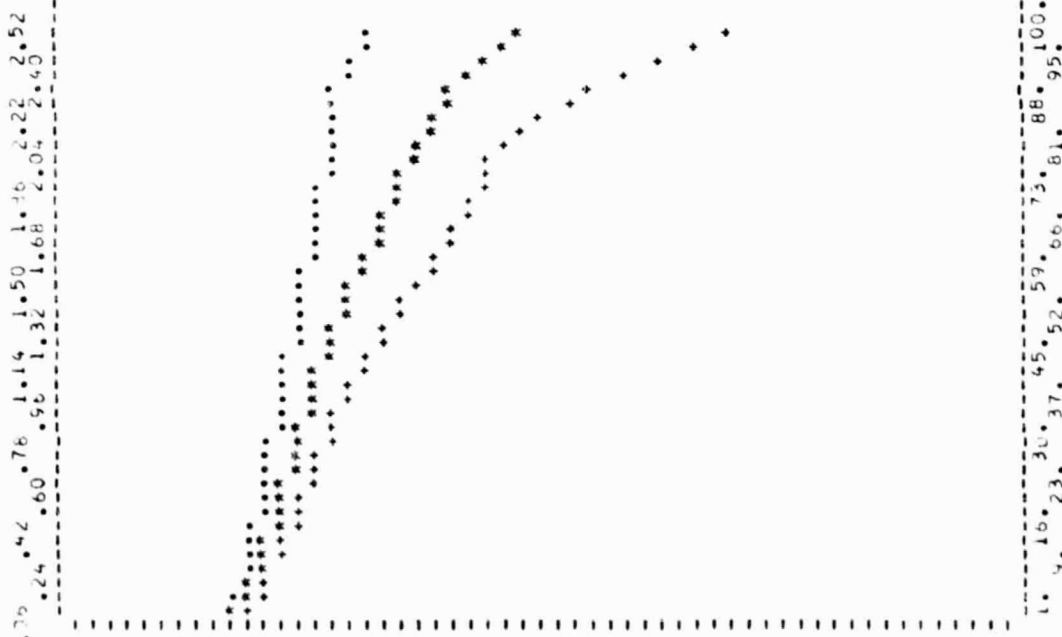
*** -- () indicates which cell

PACK NUMBER IS 2278
 SHOOT PERIOD IS 05
 CYCLE NUMBER IS 910
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
 HIGH CELL
 LOW CELL
 AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E



TIME IN MINUTES
 C/F/LS INCLUDED V1 V2 V3 V4 V5

FIGURE 9

AMPERE H2IR OUT

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

C	1.57	1.60
A	1.51	1.54
A	1.41	1.45
P	1.45	1.42
A	1.40	1.42
A	1.37	1.34
C	1.31	1.29
I	1.24	1.25
T	1.22	1.19
T	1.16	1.13
Y	1.10	1.07
	1.04	1.01
C	0.99	0.96
E	0.96	0.93
L	0.90	0.87
L	0.84	0.81
V	0.75	0.72
O	0.69	0.66
L	0.63	0.61
T	0.58	0.55
A	0.52	0.49
G	0.46	0.43
E	0.40	0.37
	0.34	0.31
S	0.28	0.25
C	0.20	0.17
A	0.14	0.11
L	0.08	0.05
F	0.02	0.02

TIME IN MINUTES		CELLS INCLUDED		V1		V2		V3		V4		V5	
1	2	3	4	5	6	7	8	9	10	11	12	13	14

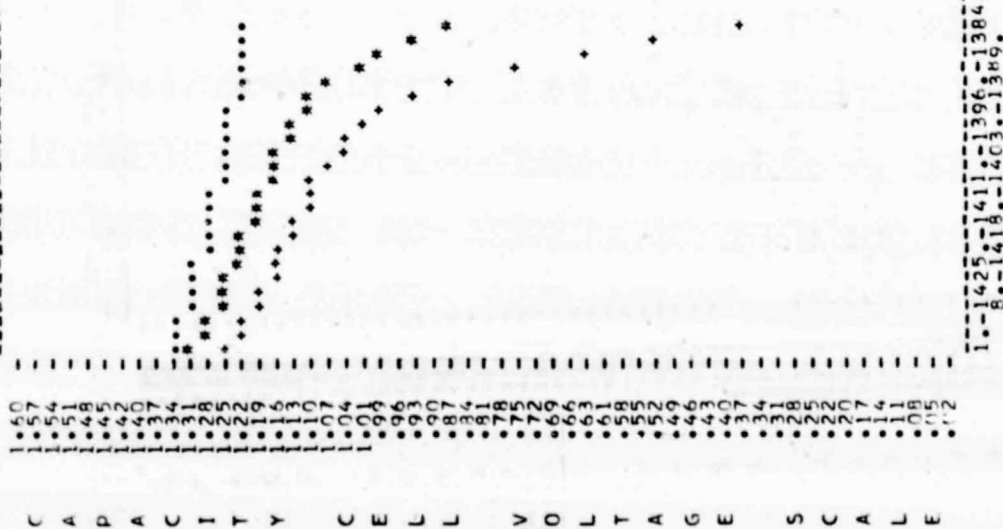
FIGURE 10

PACK NUMBER IS 227R
 SHADOW PERIOD IS 07
 CYCLE NUMBER IS 1279
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

.01 .38 .73 1.09 1.39
 .19 .55 .91 1.27



TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

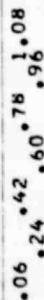
FIGURE 11

1.-1425.-1411.-1396.-1384.
 8.-1418.-1403.-1389.

PACK NUMBER IS 227B
SHADOW PERIOD IS 08
CYCLE NUMBER IS 01435
DISCHARGE RATE IS 1.35

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE



C	97
A	374
A	518
P	445
A	420
A	407
C	334
I	149
I	222
T	296
T	130
Y	107
	04
C	09
E	96
E	93
L	90
L	84
V	88
V	75
O	72
O	69
L	66
L	63
T	58
T	53
A	49
G	46
E	43
S	37
S	34
C	22
C	20
A	17
A	14
L	11
E	08
E	05
	02

1.	15.	30.	42.
8.	23.	37.	

	V-1	V-2	V-3	V-4	V-5
TIME IN MINUTES					
CELLS INCLUDED					

FIGURE 12

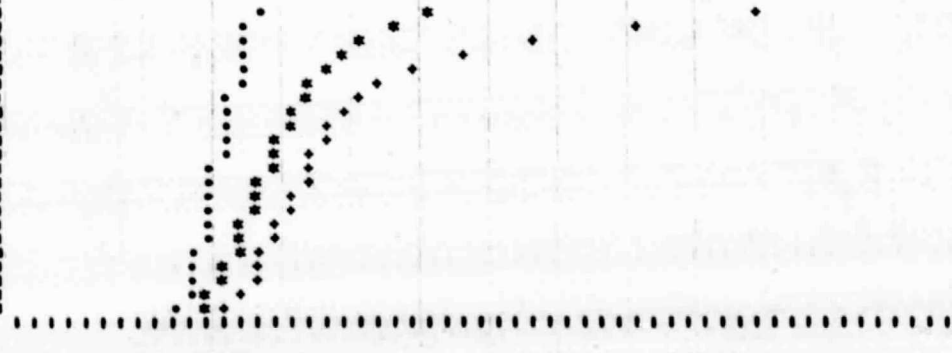
PACK NUMBER IS 227B
 SHADOW PERIOD IS 9
 CYCLE NUMBER IS 1598
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

.04 .22 .39 .57 .75 1.10 1.28

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 9. 16. 23. 30. 37. 44. 52.

CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 13

KEY HIGH CELL
• LOW CELL
• AVERAGE

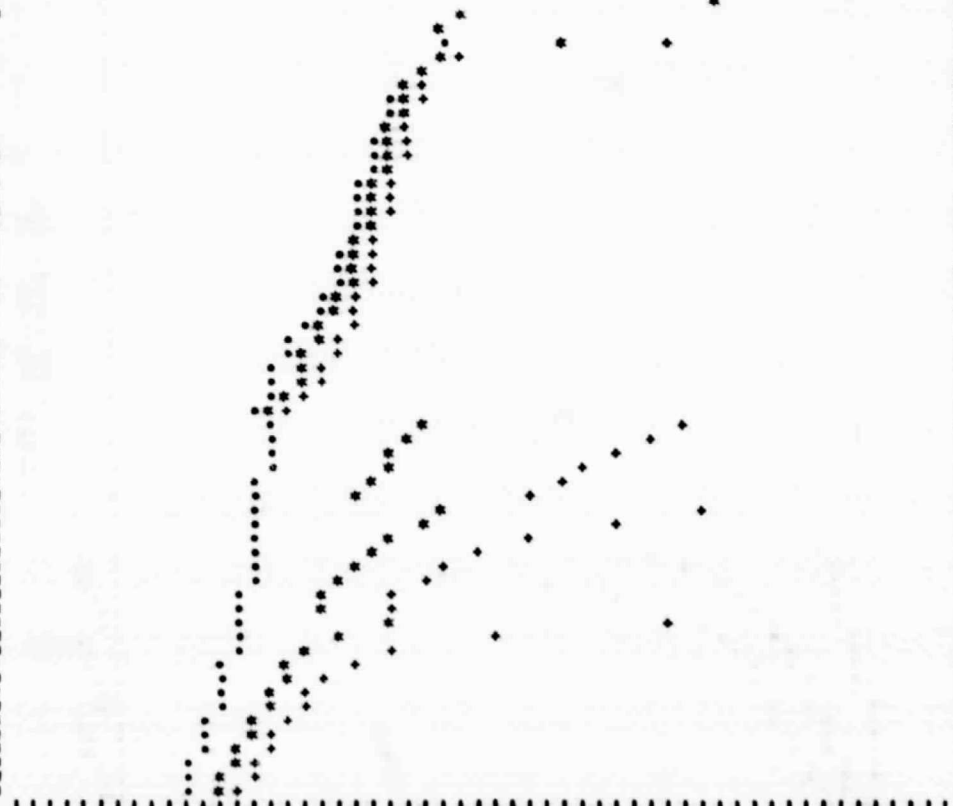
BACK NUMBER IS 227B
SHADOW NUMBER IS 10
CYCLE NUMBER IS 1779
DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

0.06 .24 .42 .60 .78 1.05 1.38 1.68 2.04 2.22 2.40 2.58 2.76 3.09 3.21

C A P A C I T Y C E L L V O L T A G E S C A L E

07 05 41 54 18 35 20 37 31 33 22 22 22 11 16 30 10 07 00 00 01 99 99 90 84 18 55 72 99 03 18 55 55 46 30 37 33 33 22 20 11 09 52



1. 9. 16. 23. 30. 40. 47. 54. 61. 69. 76. 83. 90. 97. 105. 119. 133. 138.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 14

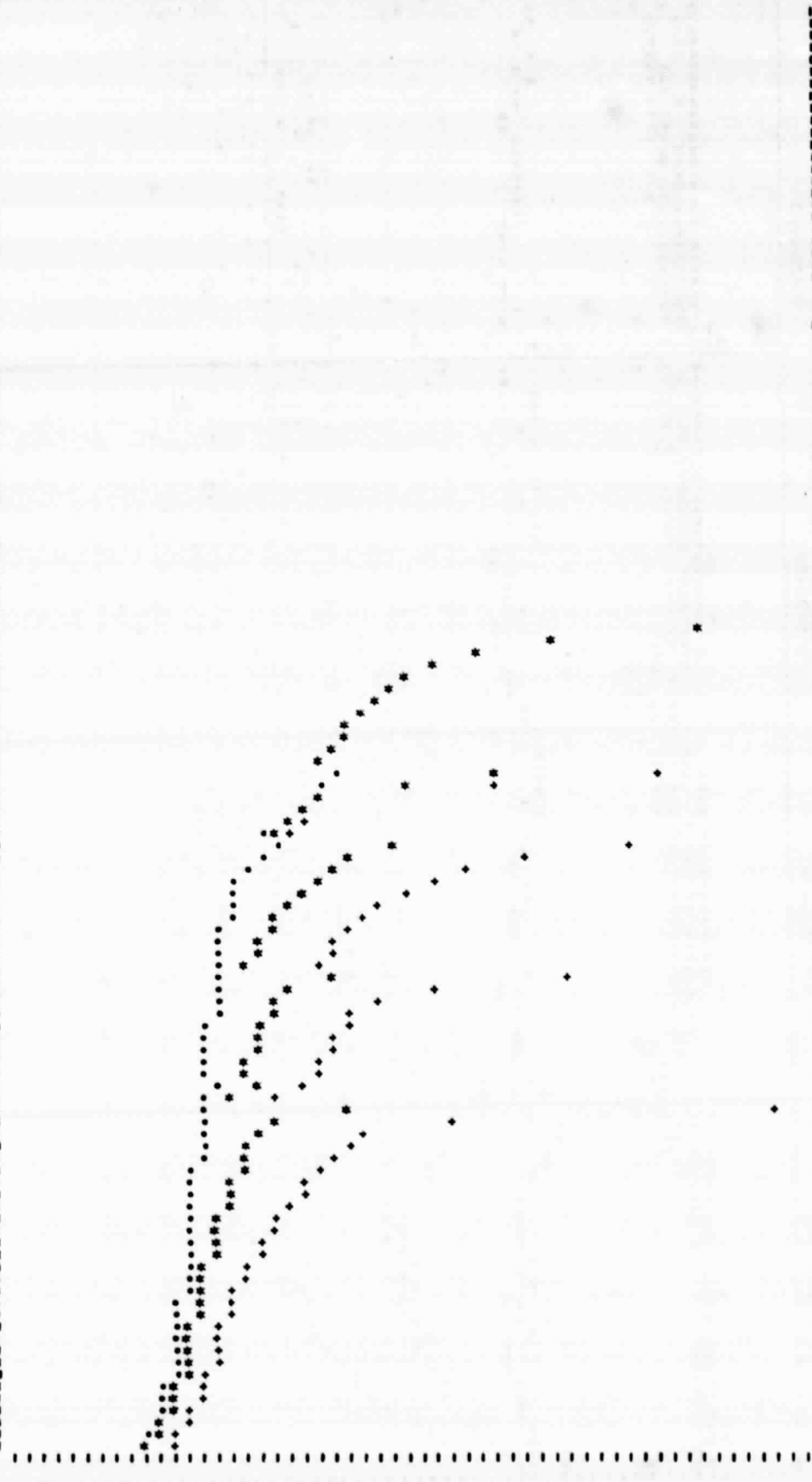
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 227B
 POST CYCLING
 CYCLE NUMBER IS 1780
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

04 .22 .41 .59 .77 1.14 1.51 1.81 2.09 2.36 2.50 2.86 3.18 3.52 3.89 4.01
 .96 1.32 1.69 1.99 2.36 2.68 3.00 3.34 3.70

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 29. 44. 58. 73. 87. 101. 116. 130. 145. 159. 164.
 .22. 38. 51. 65. 79. 94. 109. 123. 137. 152.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 15

KEY HIGH END DISCHARGE VOLTAGE
 * * * * *
 * * * * *
 * * * * *
 * * * * *
 * * * * *
 * * * * *
 * * * * *
 * * * * *
 * * * * *
 * * * * *

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 03
 EAGLE PITCHER CELLS

SERIAL 485 487 492 521 523
 PROJECT SMS

PACK = 2278

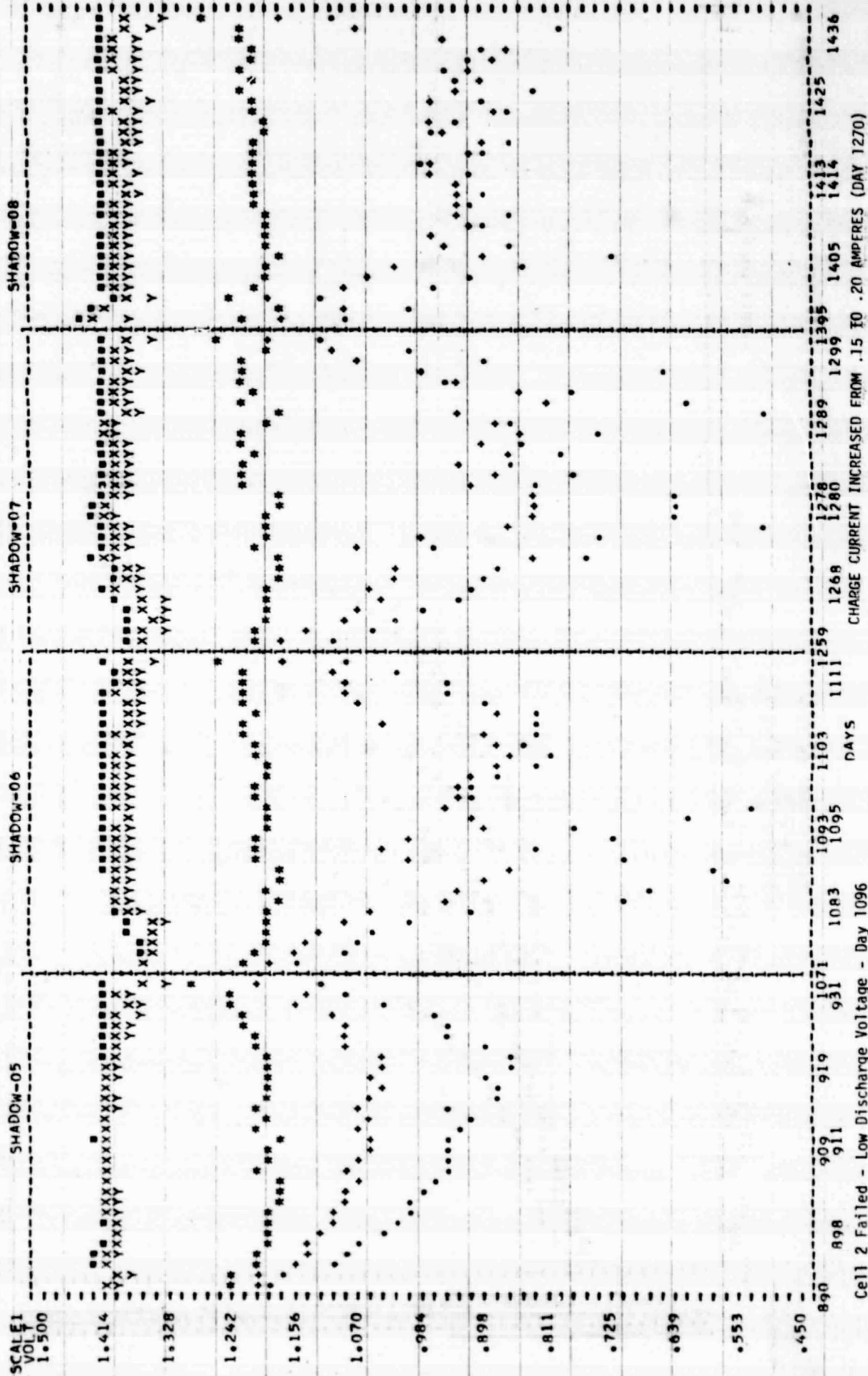


FIGURE 16

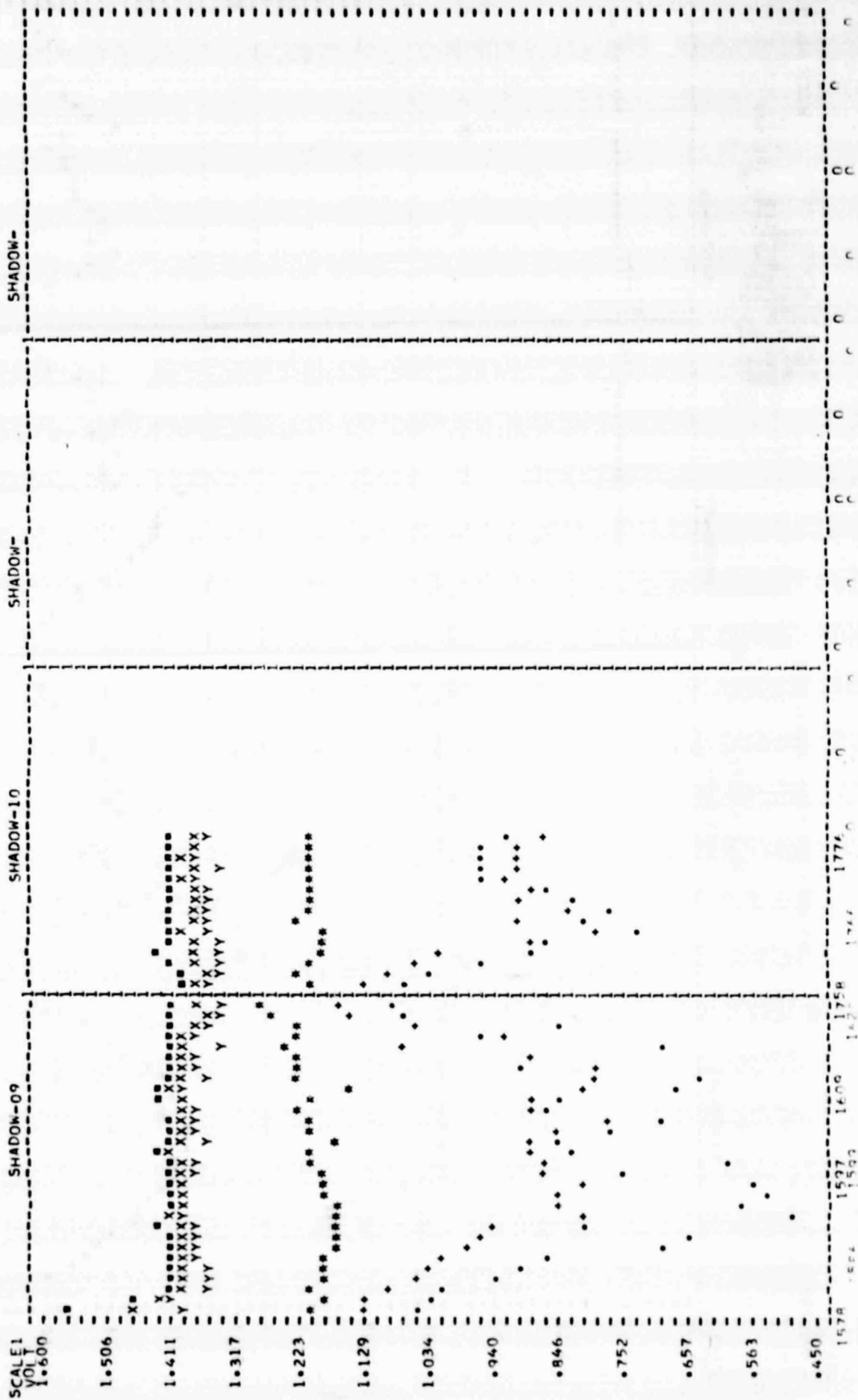
KEY
 ● HIGH END DISCHARGE VOLTAGE
 ◆ AVE END DISCHARGE VOLTAGE
 ● LOW END DISCHARGE VOLTAGE
 ● HIGH EOC
 X AVE EOC
 Y LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 03
 EAGLE PITCHER CELLS

SERIAL 485 487 492 521 523
 PROJECT SMS

PACK = 227B

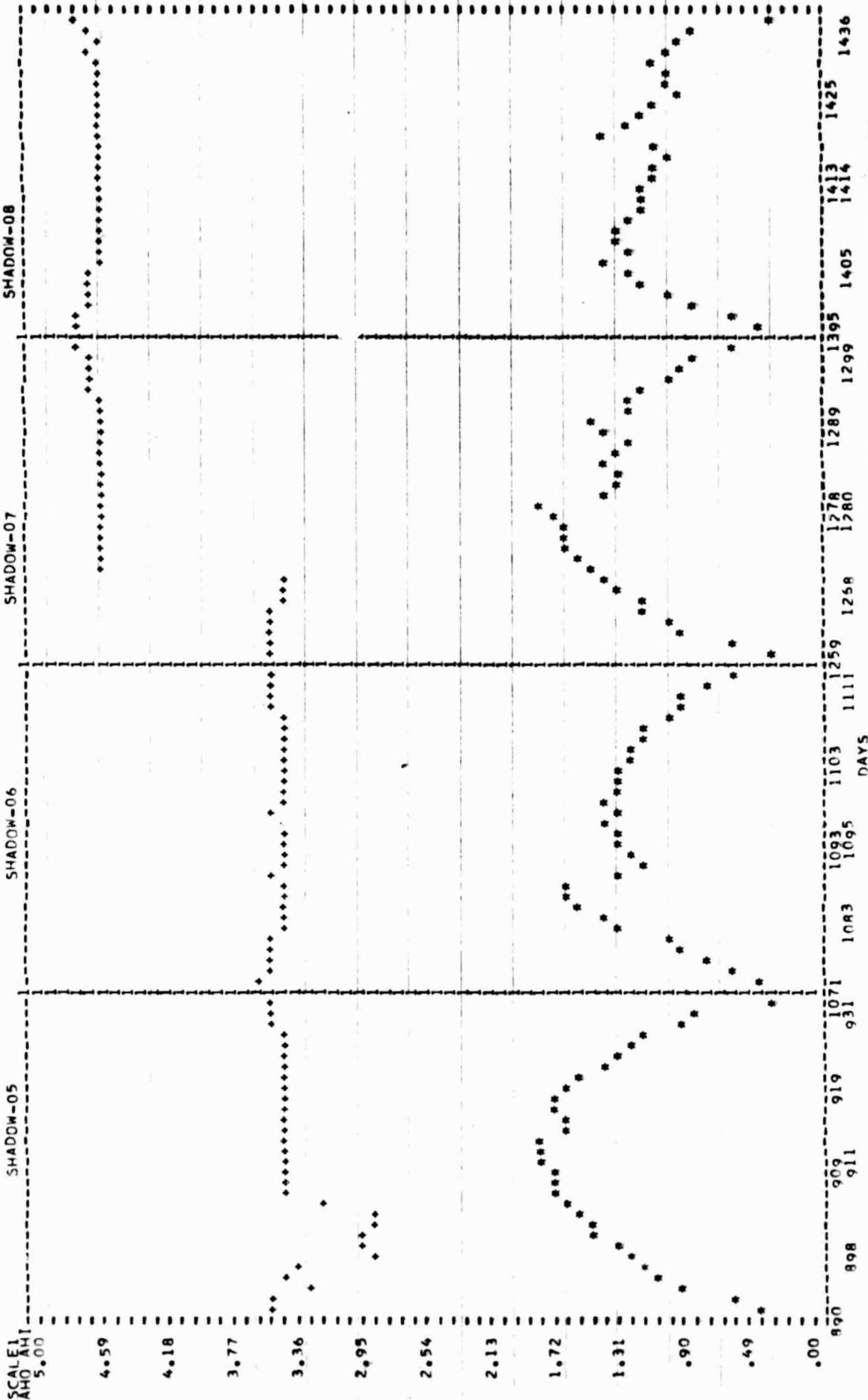


KEY
* AHO
+ ANY-TOTAL

SYNCHRONOUS ORRIT SHADOW PILOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
TEMPERATURE 20
AMPERE RATE 03
EAGLE PITCHER CELLS
SERIAL 485 487 492 521 523
PROJECT SMS

PACK = 227B



CHARGE CURRENT INCREASED FROM .15 TO .20 AMPERES (DAY 1270)

FIGURE 18

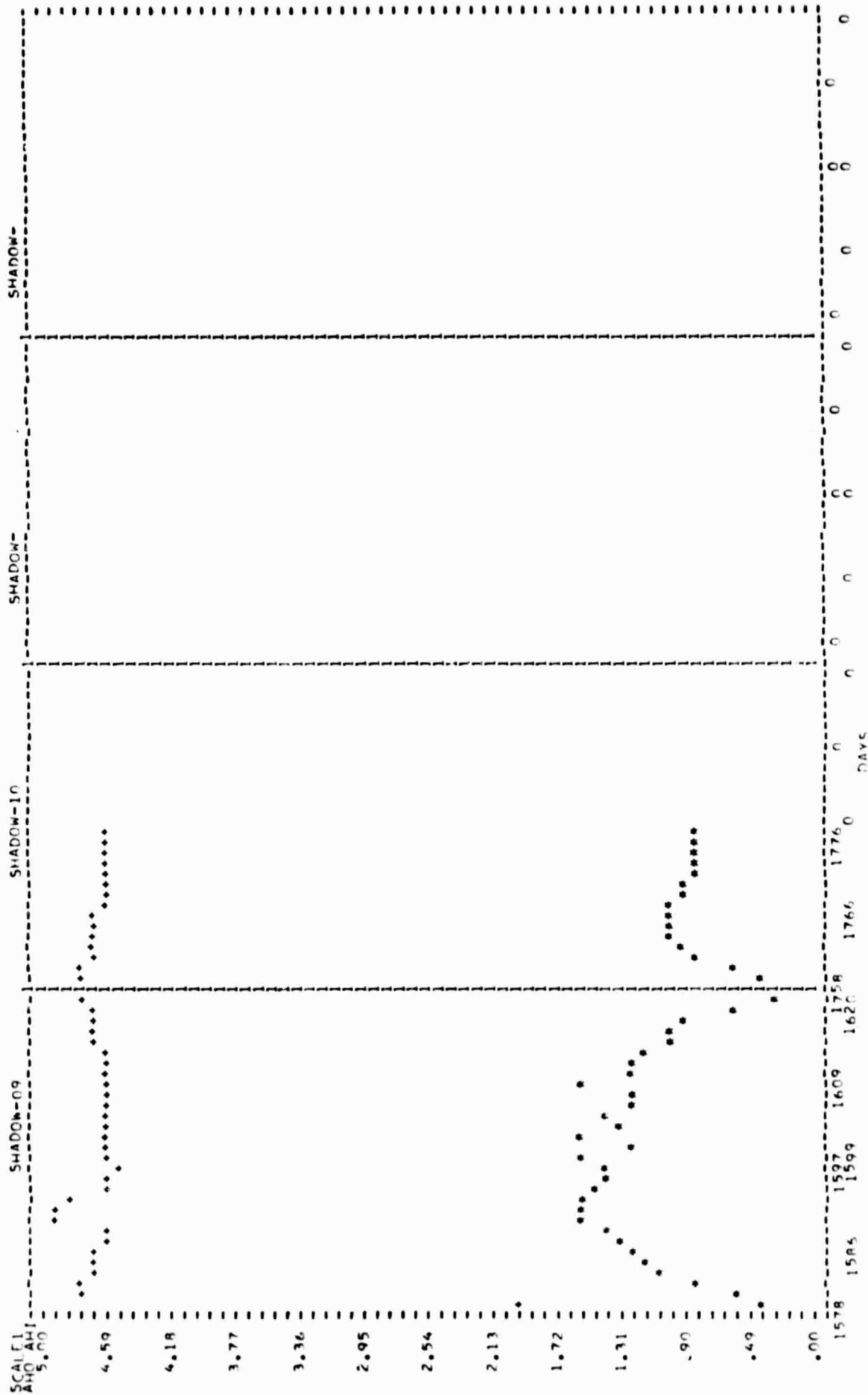
KEY
 • A10
 • A11-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50
 TEMPERATURE 20
 AMPERE RATE 03
 SINGLE PITCHED CELLS
 SERIAL 485 487 492 521 523
 PROJECT SMS

WQEC/C 81-120A

PACK = 227B



3. Pack 227C, 5-cells (GOES B & C)

a. Cell information:

(1) The cells were manufactured to Aeronutronic-Ford's "Nickel-Cadmium Battery Cell (3.0 ampere-hour) Procurement Specification", No. SP-212064C Amendment 1, Addendum SE-237904A. These cells were from EP lots #10 and #12. Cells from these lots are intended for use in GOES B & C batteries (S/N 1013, 1014, 1015, 1016 and 1017), manufactured by Aeronutronic-Ford Corporation. The cells were tested at Aeronutronic-Ford in accordance with "Battery Cell Screening Procedure", SC-2137281B, Addendum SC-237903, Amendment 1. The purpose of this test is to verify the performance and life of these cell lots and to provide cell characteristic data which will assist in establishing procedures for operation of the batteries in orbit. The results of the first eclipse season were reported in the Crane Report WQEC/C 77-134 of 9 June 1977.

b. Parameters:

| | | | |
|------------------------|-----|--------------------------|------|
| Depth of Discharge (%) | 60 | Discharge Current (amps) | 1.5 |
| Charge Control | CC | Temperature (°C) | 20 |
| Charge Current (amps) | .15 | Float Current (amps) | .085 |

c. Capacity Checks: (Discharge each cell to .75 volts)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Precycling* | 1.012 | .996 | .923 | .871 | .875 | 4.23 |
| Shadow 1 | .420 | | | | | 4.17 |
| Shadow 2 (Figure 20)** | .615 | .990 | | | | 4.10 |
| Shadow 3 (Figure 21) | 4.10 | | | | | |
| Shadow 4 (Figure 22) | 3.86 | 4.02 | 4.23 | | | |
| Shadow 5 (Figure 23) | 3.67 | | | | | |
| Shadow 6 (Figure 24) | 3.52 | 3.52 | | | | |
| Shadow 7 (Figure 25) | 3.51 | | | | | |
| Shadow 8 (Figure 26) | 3.31 | 3.60 | 3.85 | | | |
| Shadow 9 (Figure 27) | 3.18 | | | | | |
| Shadow 10 (Figure 28) | 2.92 | 3.33 | | | | |
| Shadow 11 (Figure 29) | 2.67 | | | | | |

* -- Discharge to 5.0 volts pack voltage

** -- Discharge till any cell reaches .75 volts

d. Test results during the Shadow Periods: (Figures 30 to 35)

(1) End of Discharge Voltages: The average mid-shadow voltages, prior to the capacity check, have steadily decreased from 1.209 (shadow 1) to 1.070 volts (shadow 11). Cell 4 has always exhibited the lowest voltage. The 30 to 50 millivolt increase in the high cell voltage, following the capacity checks, is exhibited by those cells which were capacity checked; and the decrease in voltage is due to the other cells being on open-circuit for 24 hours during the capacity checks.

(2) Capacity/Reconditioning Effects: Cell 1, which is capacity checked each shadow, has degraded 36 percent in capacity from shadow 1 to shadow 11. Cells 2 and 3 have not degraded as much in capacity as they have in voltage; in that from shadows 4 to 10, their capacity to 1.10 volts is less than cell 1's. During shadow 10, the percent of cell 1's capacity below the 1.00 volt level was 16.4 and cell 2's was 23.0. The reconditioning effect, due to the capacity checks, is more pronounced at the beginning and end of the shadows when comparing EOD voltages of cells 1, 2, and 3 with cells 4 and 5. This effect is not noticeable in the middle of the shadow, prior to that shadow's capacity check, as cell 4 had the lowest cell voltage and cell 5 had the highest during shadow 11. There is a reconditioning effect due to the daily discharge of the pack as is obvious from the graphs which show higher values for the low end discharge voltages during the last half of each shadow, except following the last shadow's capacity check in which cell 4's voltage remained low for 8 days.

(3) End of Charge Voltage: Cells 4 and 5 exhibited the highest voltages during shadows 1 to 9; but were in line with the other cells during shadow 10 until towards the end of the shadow when cell 5's voltage was 5 millivolts higher than the average. During shadow 11, there was a significant decrease in the voltages of cells 1 through 4 during the last 8 days of the period. Their average voltage decreased from 1.409 (day 1841) to 1.377 volts (day 1848) with cell 1 decreasing from 1.410 to 1.359 volts.

e. Performance during Sun Period: Pack has completed 10 sun periods as it began test with a shadow period. Following is a listing of the high, average, and low cell voltages at the start and end of each sun period.

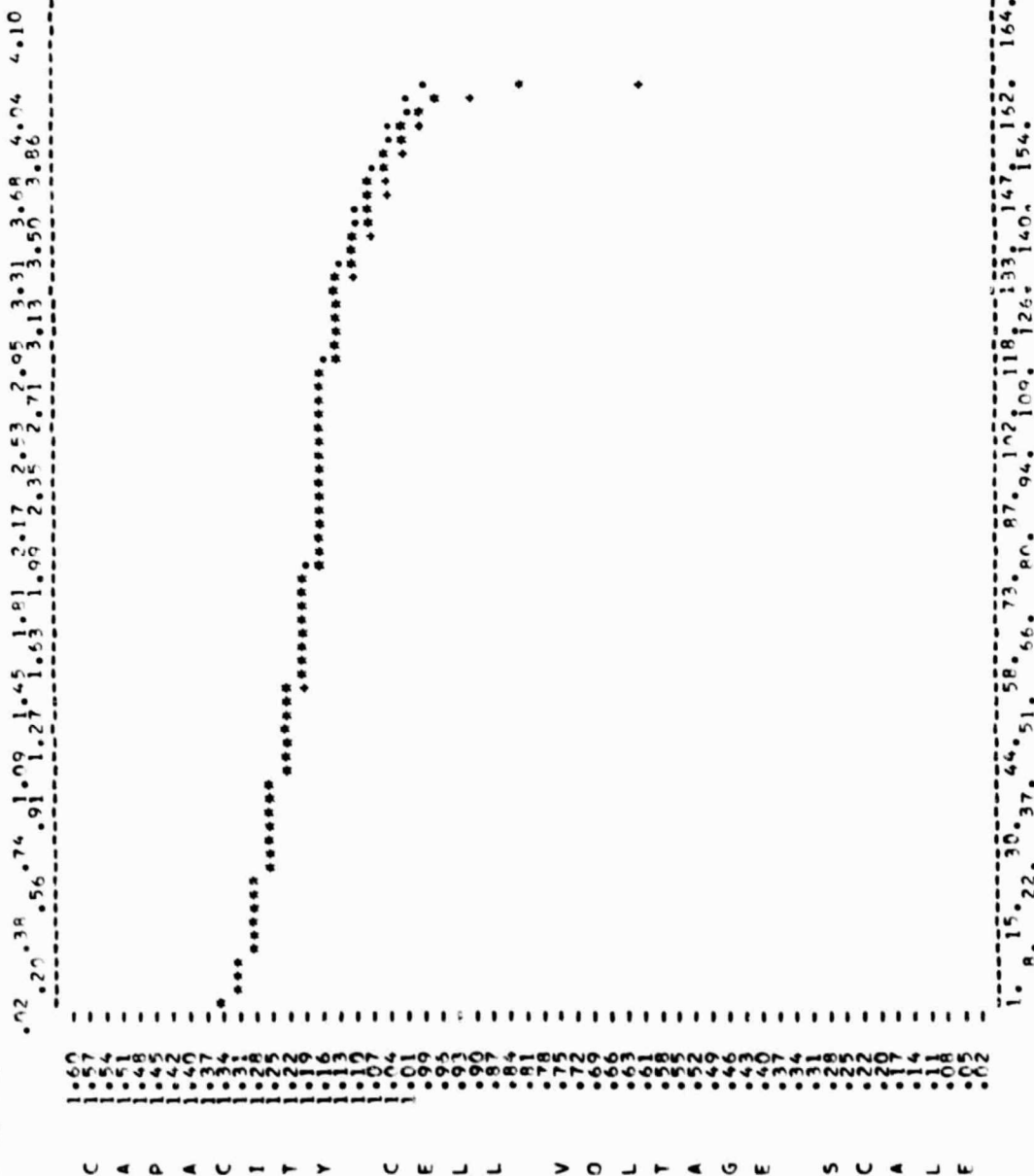
| Sun Periods | | | | | | | | | | |
|-------------|--------------|------------|--------------|------------|--------------|------------|--------------|------------|--------------|------------|
| Voltages*** | 1 | | 2 | | 3 | | 4 | | 5 | |
| | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.397(4) | 1.404(1) | 1.403(4) | 1.393(1) | 1.393(4) | 1.399(5) | 1.392(4) | 1.402(1) | 1.395(4) | 1.395(2) |
| Average | 1.394 | 1.401 | 1.399 | 1.387 | 1.391 | 1.397 | 1.388 | 1.396 | 1.391 | 1.391 |
| Low | 1.390(1) | 1.396(4) | 1.395(1) | 1.381(4) | 1.389(2) | 1.395(4) | 1.380(2) | 1.381(4) | 1.385(2) | 1.379(4) |
| Voltages*** | 6 | | 7 | | 8 | | 9 | | 10 | |
| | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.402(4) | 1.390(5) | 1.397(4) | 1.394(2) | 1.401(4) | 1.380(4) | 1.399(5) | 1.384(2) | 1.392(5) | 1.390(2) |
| Average | 1.398 | 1.386 | 1.392 | 1.390 | 1.393 | 1.377 | 1.394 | 1.378 | 1.388 | 1.382 |
| Low | 1.392(2) | 1.383(4) | 1.387(1,2) | 1.386(3) | 1.376(1) | 1.375(1) | 1.384(1) | 1.372(4) | 1.382(1) | 1.371(5) |

*** -- () indicates which cell

PACK NUMBER IS 227C
 SHADOW PERIOD IS 02
 CYCLE NUMBER IS 228
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE



TIME IN MINUTES
 CELLS INCLUDED V1 V2

FIGURE 20

HIGH CELL
 LOW CELL
 AVERAGE

PACK NO. 101-15 03
 SHADOW NO. 15 0409
 CYCLE NO. PER IS 1.5
 DISCHARGE RATE IS 1.5

WQEC/C 81-120A

AMPERE HOUR OUT

.02 .38 .74 1.11 1.47 1.83 2.19 2.55 2.91 3.33 3.68 4.04 4.10
 .20 .56 .93 1.29 1.65 2.01 2.37 2.73 3.15 3.51 3.86

1.60
 1.54
 1.51
 1.48
 1.45
 1.42
 1.40
 1.37
 1.34
 1.31
 1.28
 1.25
 1.22
 1.19
 1.16
 1.13
 1.10
 1.07
 1.04
 1.01
 .99
 .96
 .93
 .90
 .87
 .84
 .81
 .78
 .75
 .72
 .69
 .66
 .63
 .61
 .58
 .55
 .52
 .49
 .46
 .43
 .40
 .37
 .34
 .31
 .28
 .25
 .22
 .19
 .16
 .14
 .11
 .08
 .05
 .02

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1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 118. 126. 133. 140. 150. 164. 166.

TIME IN MINUTES
 CELLS INCLUDED VI

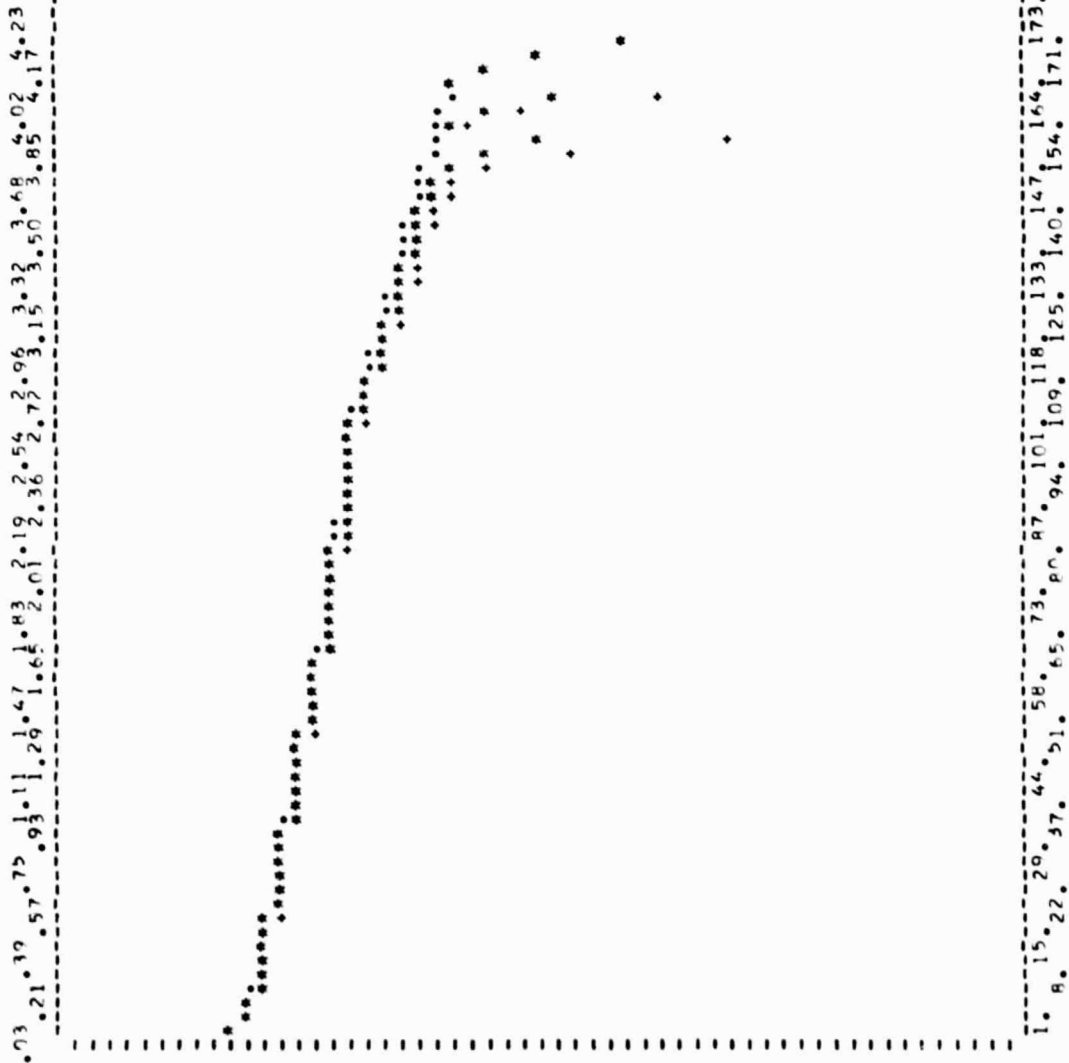
FIGURE 21

PACK NUMBER IS 227C
SHADOW PERIOD IS 04
CYCLE NUMBER IS 0597
DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

C
A
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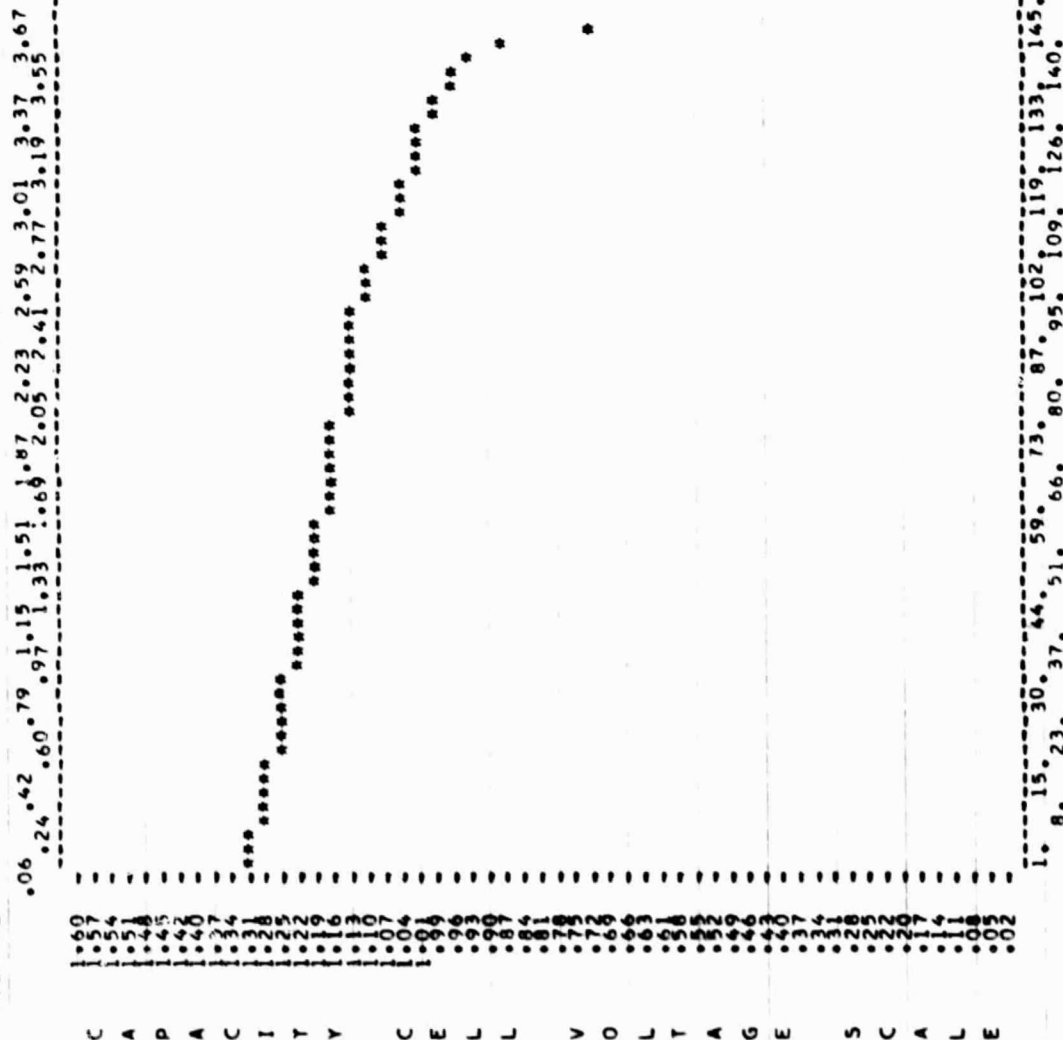
TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3

FIGURE 22

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

PACK NUMBER IS 227C
SHADOW PERIOD IS 05
CYCLE NUMBER IS 00733
DISCHARGE RATE IS 1.5

AMPERE HOUR OUT



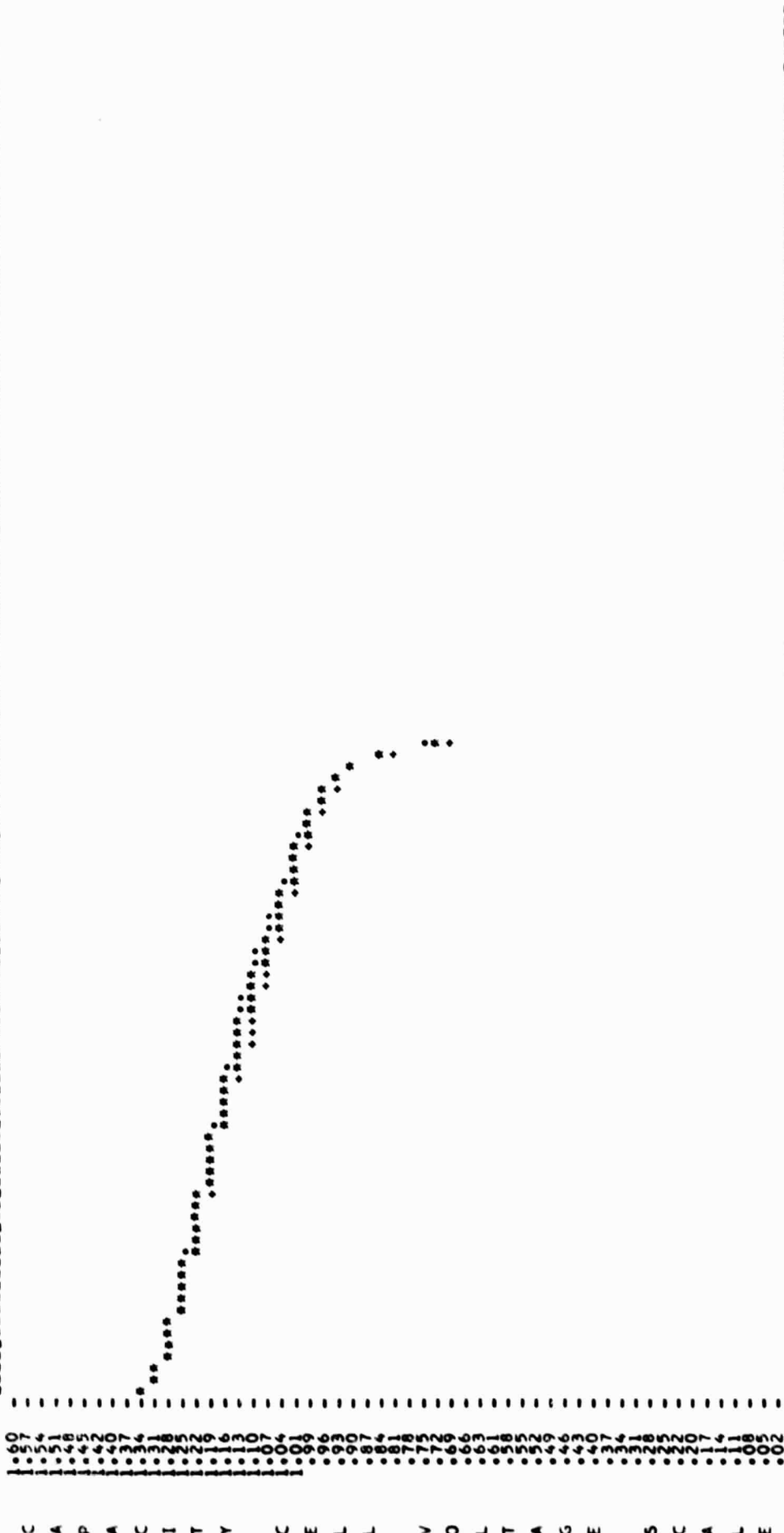
TIME IN MINUTES
CELLS INCLUDED V-I

FIGURE 23

PACK NUMBER IS 227C
 SHADOW PERIOD IS 3
 CYCLE NUMBER IS 916
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE



TIME IN MINUTES
 CELLS INCLUDED V-1 V-2

FIGURE 24

KEY HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 227C
 SHADOW PERIOD IS 07
 CYCLE NUMBER IS 1096
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

00.15.33.51.69.1.05.1.41.1.77.2.13.2.49.2.85.3.21.3.51
 .87.1.23.1.59.1.95.2.31.2.67.3.03.3.39

C A P A C I T Y C E L L V O L T A G E S C A L E
 1.60
 1.57
 1.54
 1.51
 1.48
 1.45
 1.42
 1.40
 1.37
 1.34
 1.31
 1.28
 1.25
 1.22
 1.19
 1.16
 1.13
 1.10
 1.07
 1.04
 1.01
 .99
 .96
 .93
 .90
 .87
 .84
 .81
 .78
 .75
 .72
 .69
 .66
 .63
 .61
 .58
 .55
 .52
 .49
 .46
 .43
 .40
 .37
 .34
 .31
 .28
 .25
 .22
 .20
 .17
 .14
 .11
 .08
 .05
 .02

1. 8. 16. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 109. 116. 123. 130. 138. 142.

TIME IN MINUTES
 CELLS INCLUDED V-1

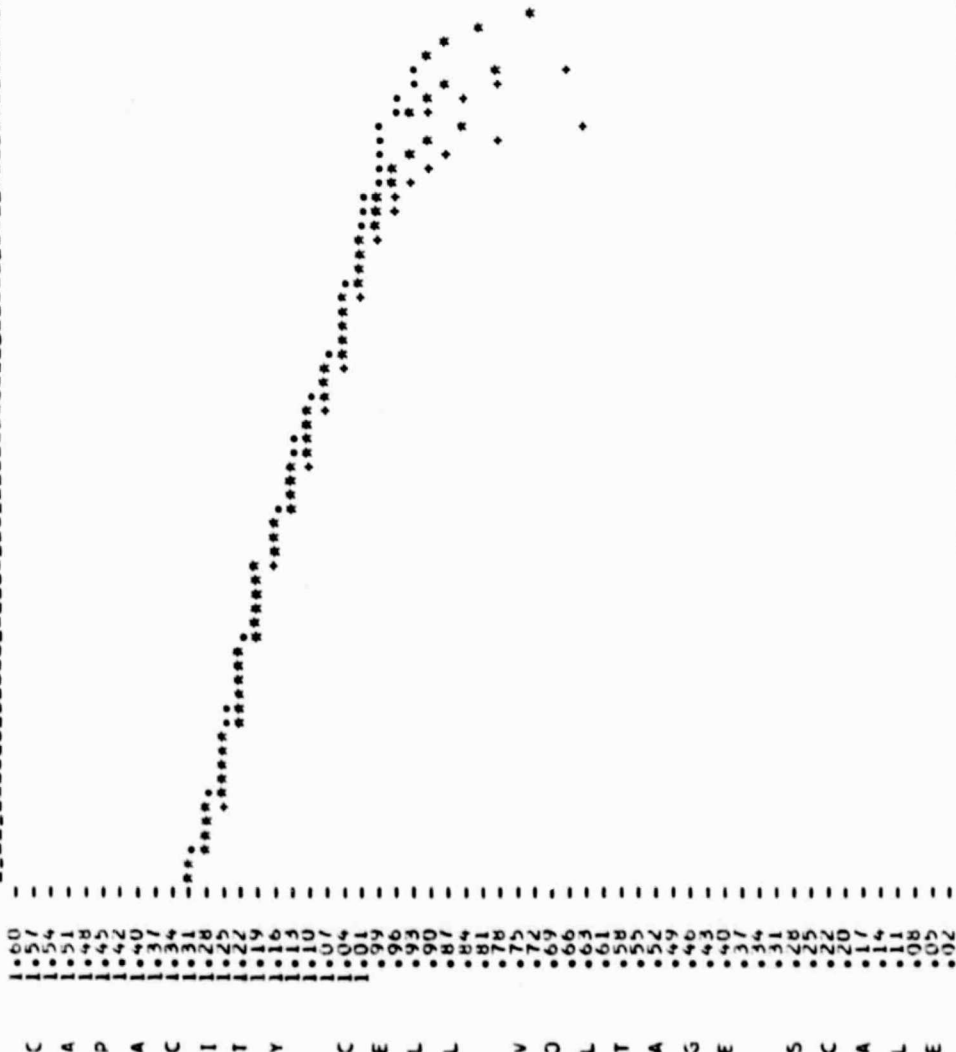
FIGURE 25

PACK NUMBER JS 227C
SHADOW PERIOD 15 08
CYCLE NUMBER 15 1279
DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

0.04 .23 .41 .60 .78 1.15 1.52 1.89 2.26 2.63 3.00 3.42 3.79 3.85
1.34 1.70 2.07 2.44 2.81 3.18 3.60



TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3

FIGURE 26

PACK NUMBER IS 227C
 SHADOW PERIOD IS 09
 CYCLE NUMBER IS 1459
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

KEY HIGH CELL
 : LOW CELL
 : AVERAGE

01 19 38 56 74 111 148 184 221 257 294 331
 1 29 166 203 240 276 312

C A A A C I T Y C E L L V D L T A G E S C A L E
 01 07 05 14 18 22 27 31 35 39 43 47 51 55 59 63 67 71 75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147 151 155 159 163 167 171 175 179 183 187 191 195 199 203 207 211 215 219 223 227 231 235 239 243 247 251 255 259 263 267 271 275 279 283 287 291 295 299 303 307 311 315 319 323 327 331 335 339 343 347 351 355 359 363 367 371 375 379 383 387 391 395 399 403 407 411 415 419 423 427 431 435 439 443 447 451 455 459 463 467 471 475 479 483 487 491 495 499 503 507 511 515 519 523 527 531 535 539 543 547 551 555 559 563 567 571 575 579 583 587 591 595 599 603 607 611 615 619 623 627 631 635 639 643 647 651 655 659 663 667 671 675 679 683 687 691 695 699 703 707 711 715 719 723 727 731 735 739 743 747 751 755 759 763 767 771 775 779 783 787 791 795 799 803 807 811 815 819 823 827 831 835 839 843 847 851 855 859 863 867 871 875 879 883 887 891 895 899 903 907 911 915 919 923 927 931 935 939 943 947 951 955 959 963 967 971 975 979 983 987 991 995 999

1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 109. 116. 123. 126.

CELLS INCLUDED V-I
 TIME IN MINUTES

FIGURE 27

WQEC/C 81-120A

PACK NUMBER IS 227C
 SHOOT PERIOD IS 15
 CYCLE NUMBER IS 1645
 DISCHARGE RATE IS 1.5

AMPERE HOUR OUT

10 24.42 .97 1.15 1.52 1.49 2.07 2.44 2.62 2.97 3.33
 .81 1.34 1.70 2.07 2.44 2.80 3.15

27
 25
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 21
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 7
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 100

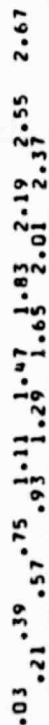
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1. 15. 30. 44. 58. 73. 87. 102. 116. 145.
 8. 15. 30. 44. 58. 73. 80. 94. 109. 138.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2

FIGURE 28

AMPERE HOUR OUT



C A A P P A A C C I I T T T V C E E L L V O O L L T T A A G G E S C C A A L L E
 657 54 51 49 47 44 42 40 37 34 32 30 27 24 22 20 17 14 13 10 07 04 01 96 93 90 87 84 81 78 75 72 69 66 63 60 57 54 51 48 45 42 39 36 33 30 27 24 21 18 15 12

ORIGINAL PAGE IS
OF POOR QUALITY

| | TIME IN MINUTES
CELLS INCLUDED V-1 | | | | | | | | | |
|----|---------------------------------------|-----|-----|-----|-----|-----|-----|------|------|--|
| 1. | 10. | 16. | 30. | 45. | 59. | 73. | 88. | 102. | 107. | |

FIGURE 29

KEY HIGH END DISCHARGE VOLTAGE
 • AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 X HIGH EOC
 Y AVE EOC
 V LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

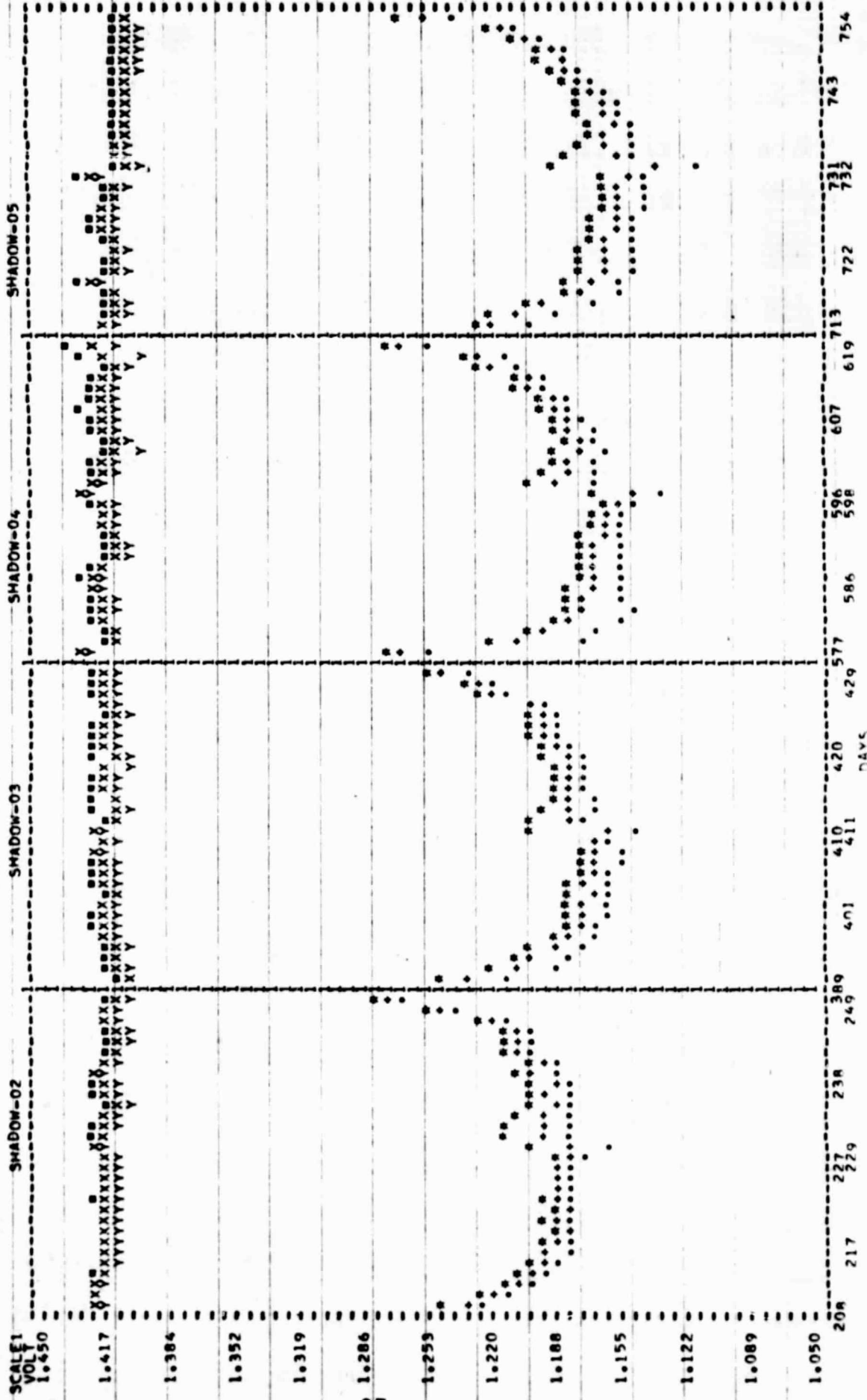
DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 03
 EAGLE PITCHER CELLS

MOEC/C 81-120A

SERIAL 775 971 800 987 836

GOES B AND C

PACK = 227C



KEY
 • HIGH END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 • HIGH END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 • HIGH END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE

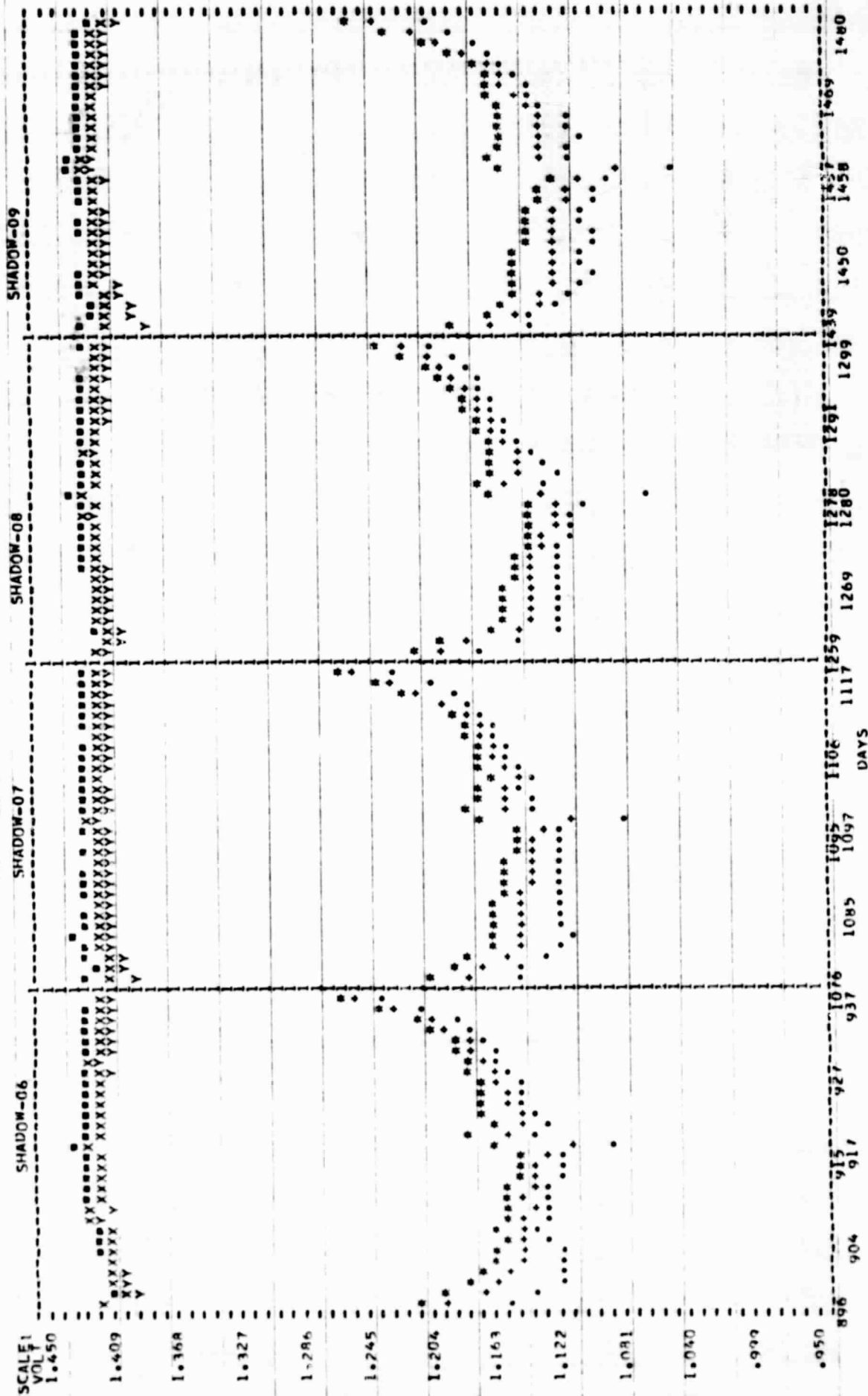
SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 MQEC/C 81-120A
 TEMPERATURE 20
 TEMPERATURE RATE 0.3
 EAGLE PICKER CELLS

SERIAL 775 971 800 987 836

GOES B AND C

PACK = 227C



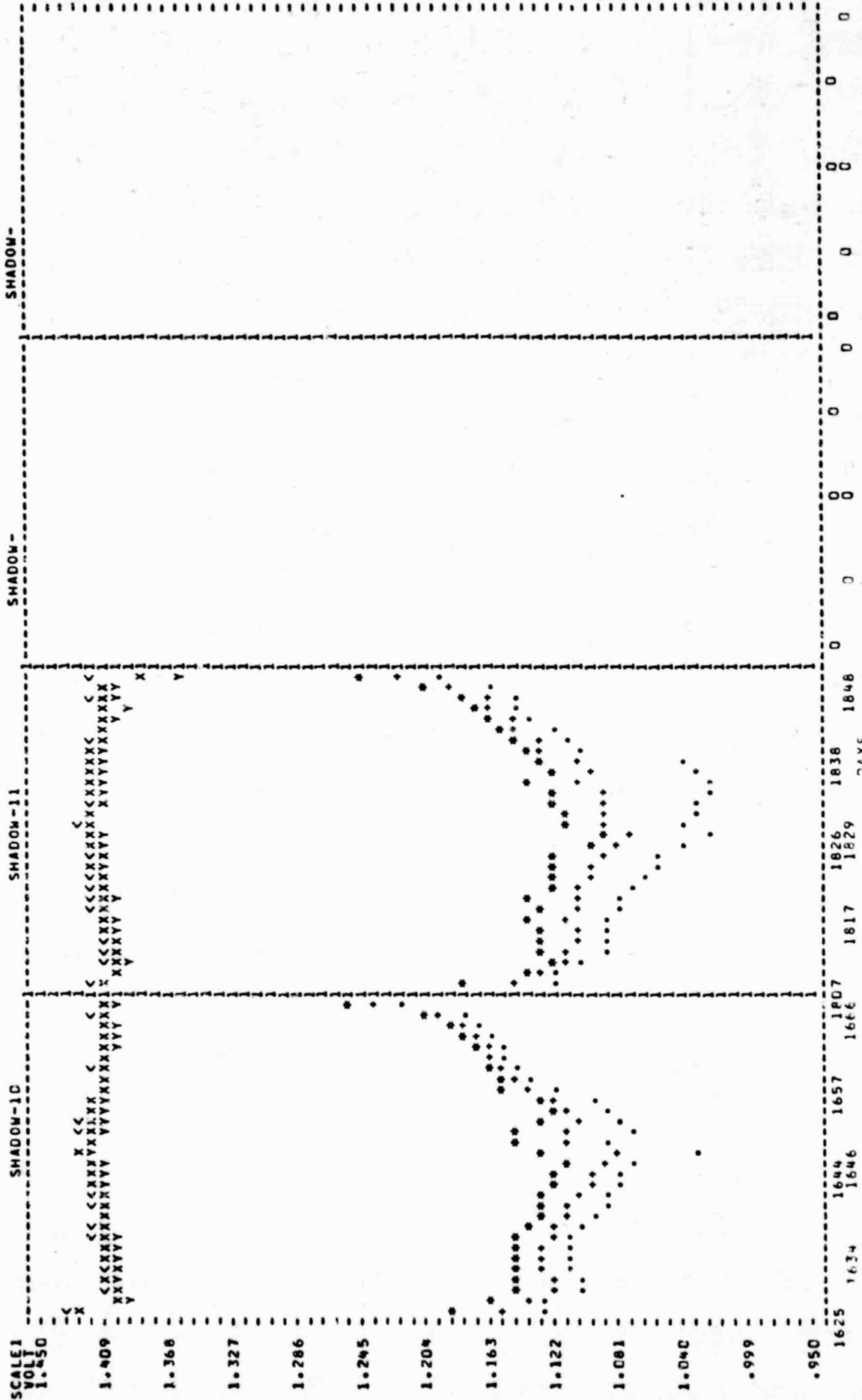
KEY HIGH END DISCHARGE VOLTAGE
 * AVE END DISCHARGE VOLTAGE
 * LOW END DISCHARGE VOLTAGE
 < HIGH EOC
 X AVE EOC
 V LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 03
 EAGLE PITCHER CELLS

SERIAL 775 971 800 987 836
 GOES B AND C

PACK = 227C



KEY
* AHQ-TOTAL
* AHQ

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
TEMPERATURE 20
AMPERE RATE 03
EAGLE PITCHER CELLS
SERIAL 775 971 800 987 836
GOES B AND C

PACK = 227C

SCALE 1
AMC AHQ
4.00

SHADOW-02

SHADOW-03

SHADOW-04

SHADOW-05

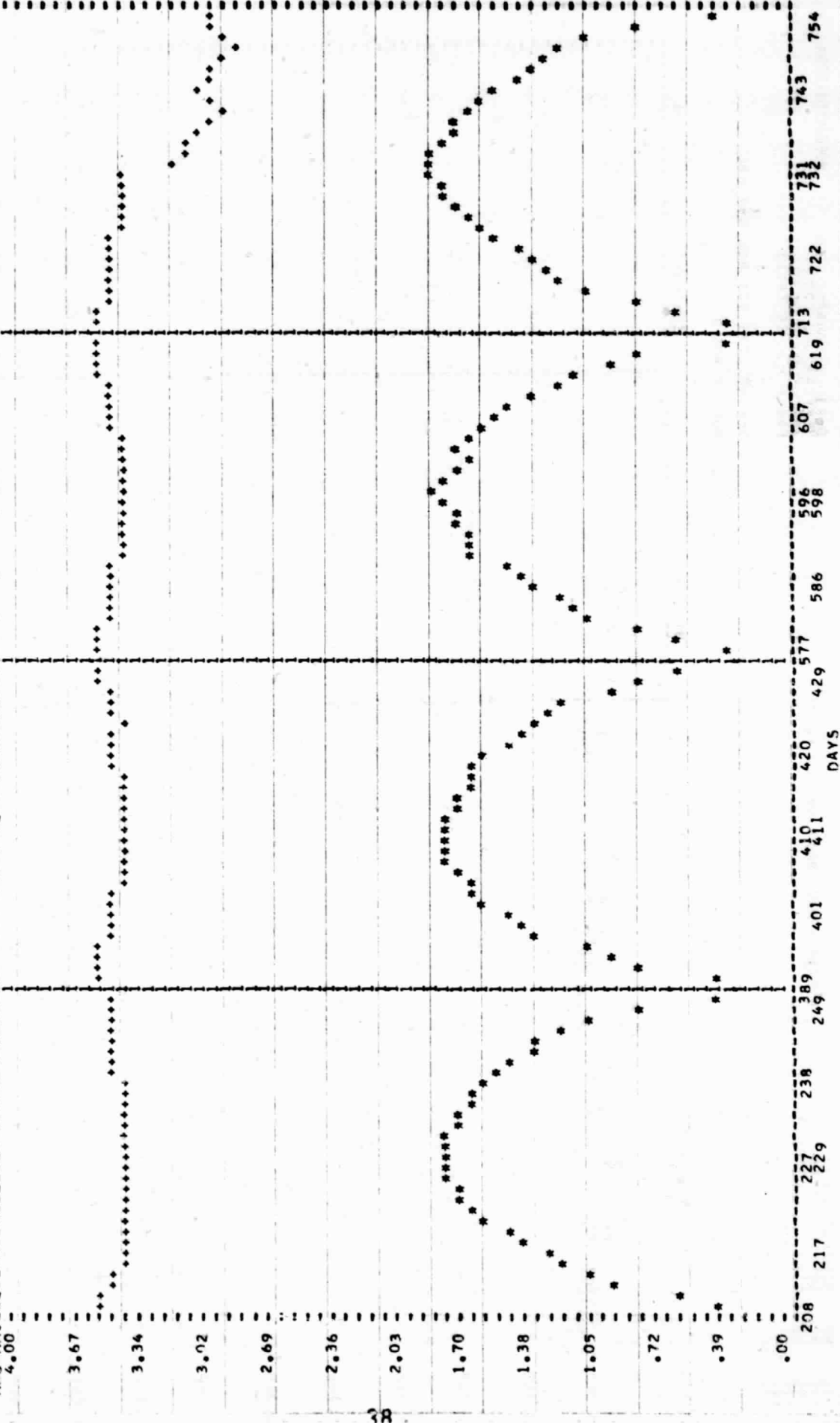


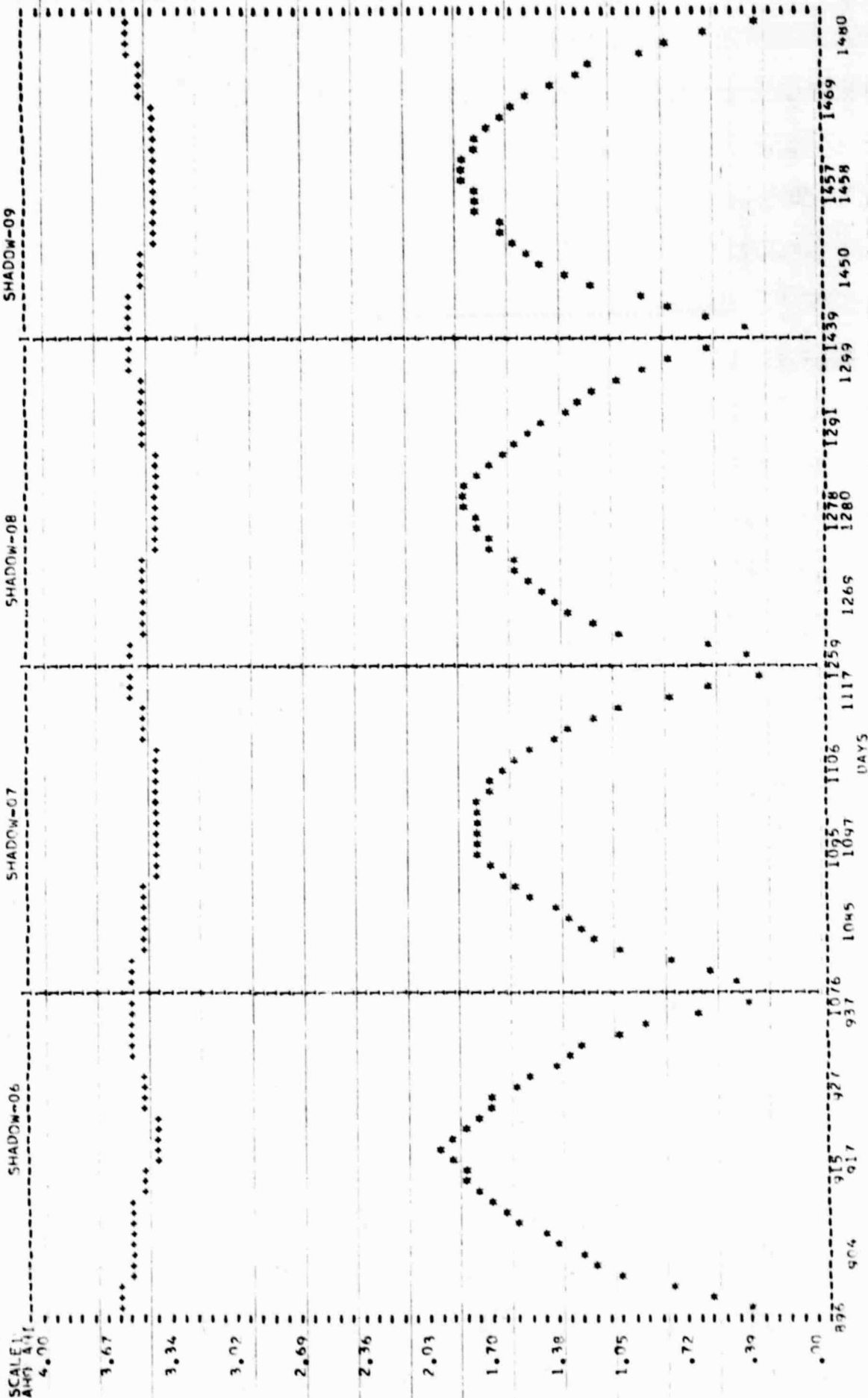
FIGURE 33

KEY
 * AHD
 * AHD - TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 20
 ALTITUDE 03
 CYCLE PICTURE CELLS
 SERIAL 775 971 800 987 836
 GOES B AND C

PACK = 227C



KEY
 * AMO
 * AMI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 20
 AMPERE RATE 03
 EAGLE PITCHER CELLS
 SERIAL 775 971 800 987 836
 GOES B AND C

PACK = 227C

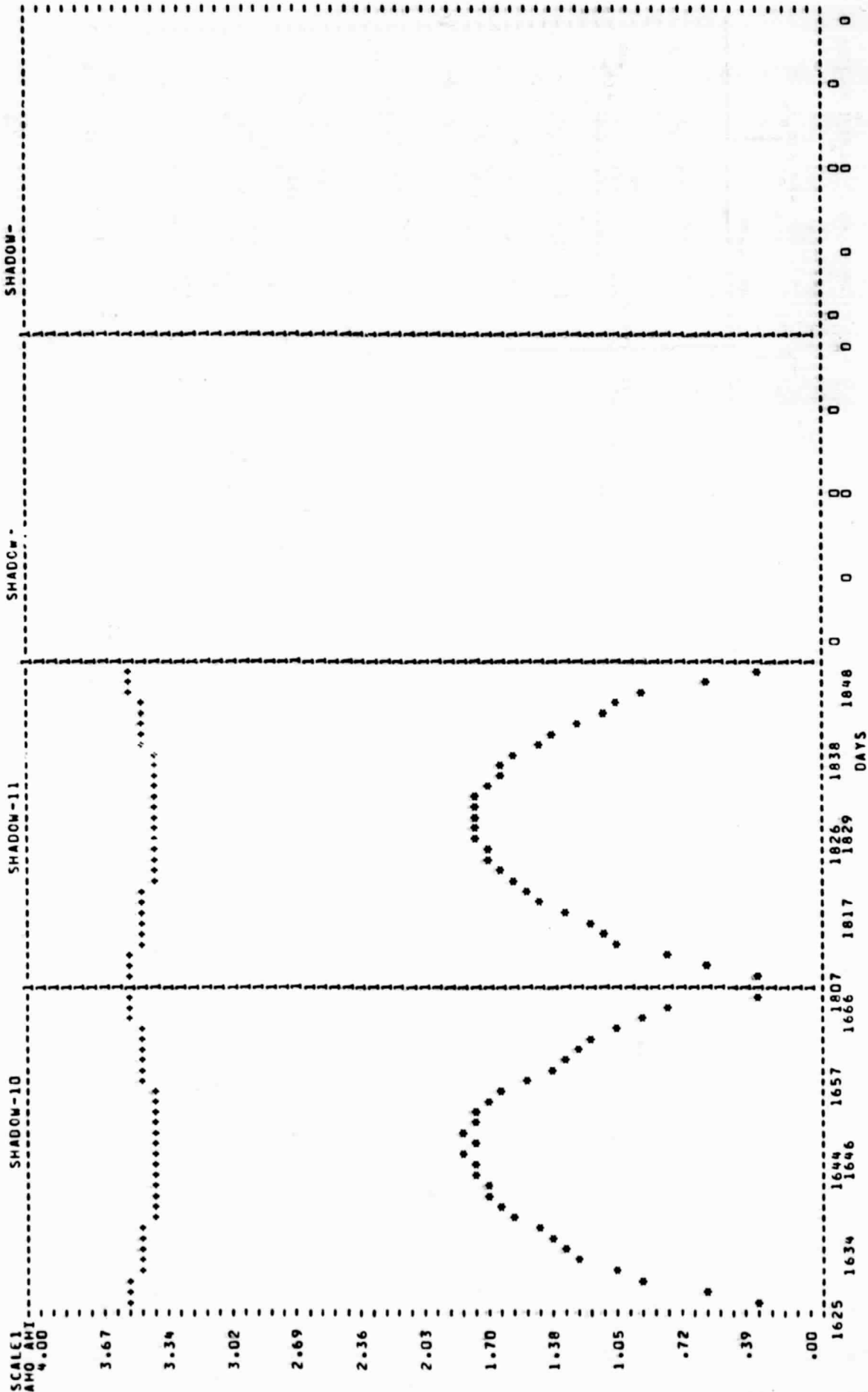


FIGURE 35

B. GE 6.0 ah

1. Pack 201A, 5-cells

a. Cell information:

(1) The cells were purchased, and provided for test, by NASA, GSFC for the purpose of establishing the life capabilities of sealed nickel-cadmium cells for communication satellites in a synchronous orbit. These cells began test on 18 July 1967. The manufacturer's catalog number is 42B006AB06. Acceptance test results and detailed cell descriptions are contained in the NAD Crane Report QE/C 67-387 of 28 June 1967. The results of the first 6 eclipse seasons were reported in the NAD Crane Report QE/C 70-634 of 14 August 1970, seasons 7 through 10 were reported in the NAD Crane Report QEEL/C 73-302 of 15 October 1973, and seasons 11 through 17 were reported in Crane Report WQEC/C 77-134 of 9 June 1977. It is noted that these cells are indicative of cell design and manufacturing practices used prior to 1970. Discussions with the manufacturer indicate several significant differences in plate design, interelectrode spacing as well as processing techniques as compared with cells made since 1970. Pack 201A was tested at 40°C, with a depth of discharge at 40 percent. The pack was discontinued following its 11th eclipse season during which 3 cells failed.

2. Pack 202A, 5-cells

a. Cell information: (Same as Pack 201A, Section V.B.1.)

b. Parameters:

| | | | |
|------------------------|-----|--------------------------|-----|
| Depth of Discharge (%) | 40 | Discharge Current (amps) | 2.0 |
| Charge Control | CC | Temperature (°C) | 25 |
| Charge Current (amps) | .20 | Float Current (amps) | .20 |

c. Capacity checks: (Discharge to .50 volts any cell or to an average voltage of 1.00 volts per cell, whichever occurs first.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|--------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Shadow 11 | | | | | * | 3.23 |
| Shadow 12 | 1.048 | .677 | 1.146 | 1.028 | | 3.86 |
| Shadow 13 | 1.225 | 1.004 | 1.162 | .634 | | 3.28 |
| Shadow 14 | .998 | .813 | 1.152 | 1.034 | | 3.49 |
| Shadow 15 | 1.089 | 1.057 | 1.165 | .003 | | 4.90 |
| Shadow 16 | .808 | .423 | 1.110 | ** | | 3.90 |
| Shadow 17 | .793 | .415 | 1.104 | | | 3.60 |
| Shadow 18 (Figure 36) | .851 | .453 | 1.122 | | | 3.48 |
| Shadow 19 (Figure 37) | .895 | .456 | 1.106 | | | 3.73 |
| Shadow 20 (Figure 38) | .844 | .453 | 1.112 | | | 3.56 |
| Shadow 21 (Figure 39) | .749 | .455 | 1.116 | | | 3.23 |
| Shadow 22 (Figure 40) | 3.50 | 3.13 | 5.34 | | | 3.13 |
| Post Cycling (Figure 41) | 3.40 | 0.00 | 3.78 | | | |

*--Removed for analysis prior to shadow 8

**--Failed, 5th day of shadow 16

d. Test results during the Shadow Periods: (Figures 42 to 47).

(1) Cell 4 failed on day 3010 of shadow 16. It was allowed to remain in the circuit and reverse during discharge. It shorted during charge on day 3012. Cell 5 was removed for analysis prior to shadow 8.

(2) End of Discharge Voltages: The reconditioning effect, due to the capacity checks during shadows 18 to 21, was that the cells averaged 19 to 26 millivolts higher at the end of discharge following the capacity check than they were before the capacity check. The low voltages, at the beginning of shadow 13, was due to the pack being discharged too long.

(3) End of Charge Voltages: There was wide divergence during each shadow period which diminished after the capacity check. This was the trend since shadow 6.

(4) The pack was discontinued in the middle of shadow 22 in which each cell was discharged to .500 volts.

(5) Post Cycling: Cell 2's voltage did not exceed .10 volts, during the .20 amp charge for 24 hours at 25°C, prior to the capacity check. Cell 2 had exhibited the highest EOC and the lowest EOD voltage since shadow 16.

e. Performance during Sun Periods: The pack began test with a sun period and completed 22 periods. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 11 through 22.

Sun Periods

| Voltages*** | | | 11 | | 12 | | 13 | | 14 | |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|-------|-----|
| High | Start | End | Start | End | Start | End | Start | End | Start | End |
| Average | 1.405(2) | 1.420(3) | 1.406(2) | 1.415(2) | 1.440(2) | 1.411(1) | 1.415(1) | 1.459(3) | | |
| Low | 1.395 | 1.391 | 1.395 | 1.398 | 1.419 | 1.399 | 1.410 | 1.426 | | |
| | 1.373(4) | 1.347(4) | 1.381(4) | 1.370(4) | 1.394(4) | 1.385(4) | 1.404(4) | 1.353(4) | | |

| Voltages | | | 15 | | 16 | | 17 | | 18 | |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|-----|
| High | Start | End | Start | End | Start | End | Start | End | Start | End |
| Average | 1.439(1) | 1.398(4) | 1.406(1) | 1.403(1) | 1.427(2) | 1.400(2) | 1.463(2) | 1.402(3) | | |
| Low | 1.425 | 1.395 | 1.401 | 1.389 | 1.419 | 1.392 | 1.433 | 1.398 | | |
| | 1.406(4) | 1.389(2) | 1.389(4) | 1.372(4) | 1.399(1) | 1.384(1) | 1.416(1) | 1.393(2) | | |

| Voltages | | | 19 | | 20 | | 21 | | 22 | |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|-----|
| High | Start | End | Start | End | Start | End | Start | End | Start | End |
| Average | 1.506(2) | 1.395(3) | 1.486(2) | 1.386(3) | 1.484(2) | 1.389(3) | 1.446(2) | 1.395(3) | | |
| Low | 1.456 | 1.391 | 1.452 | 1.381 | 1.437 | 1.388 | 1.429 | 1.392 | | |
| | 1.430(3) | 1.388(2) | 1.433(3) | 1.376(2) | 1.406(3) | 1.387(2) | 1.410(3) | 1.388(2) | | |

***--() indicates which cell

f. Cell Analysis:

(1) Visual analysis of cell 5 which completed 7 eclipse seasons, showed very little separator or plate deterioration, slight migration, and the cell was moist. Photographs were included in the 9 June 1977 report.

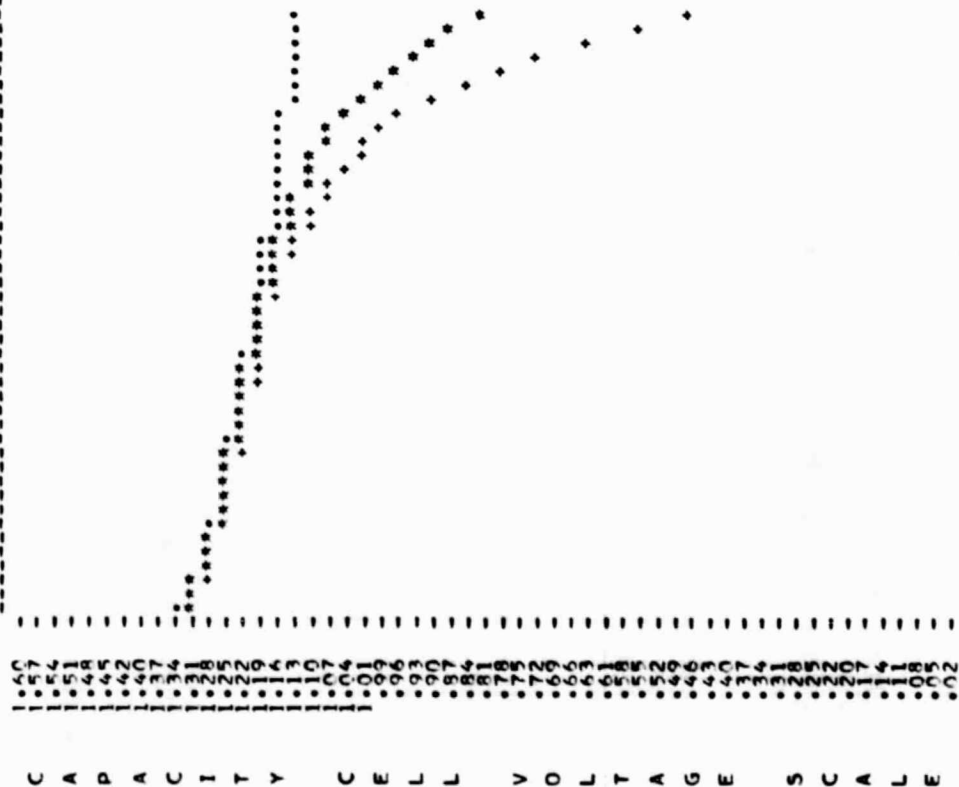
(2) One cell was sent to GSFC and another to GE for analysis. The remaining cells were disposed of.

PACK NUMBER IS 202A
 SHADOW PERIOD IS 18
 CYCLE NUMBER IS 3397.
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KFY HIGH CELL
 * LOW CELL
 * AVERAGE

1. 9. 32. 57. 91. 1.30 1.54 2.02 2.51 3.00 3.48
 2. 16. 23. 37. 44. 59. 66. 73. 80. 88. 95. 103.



TIME IN MINUTES
 CELLS INCLUDED V1 V2 V3

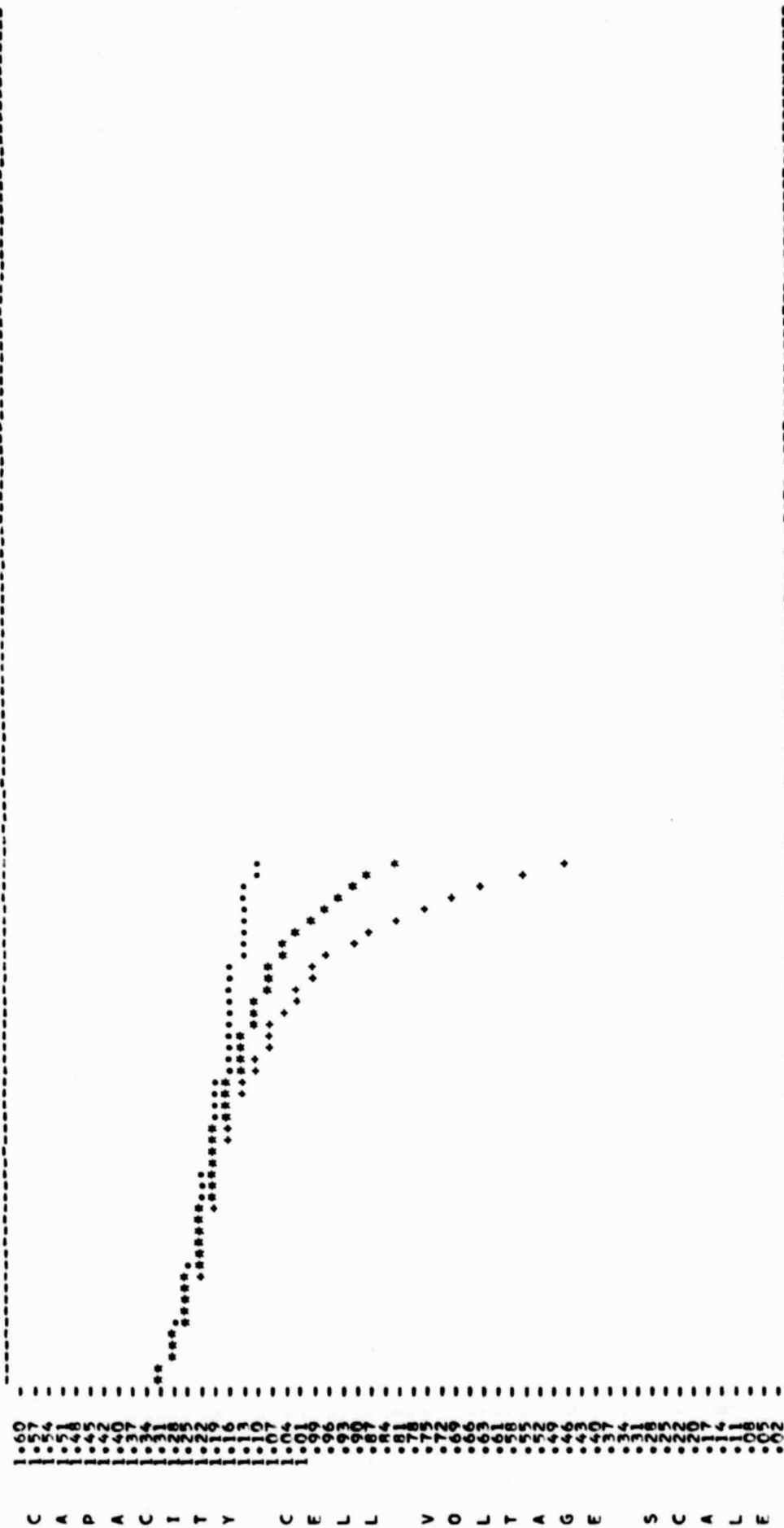
FIGURE 36

PACK NUMBER IS 202A
 SHADOW PERIOD IS 10
 CYCLE NUMBER IS 3578
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

0.78 32.57 1.05 1.54 2.02 2.51 3.00 3.48
 .91 1.30 1.78 2.27 2.75 3.24 3.73



1. 8. 15. 22. 31. 37. 44. 51. 58. 66. 73. 87. 94. 109.

TIME IN MINUTES
 CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 37

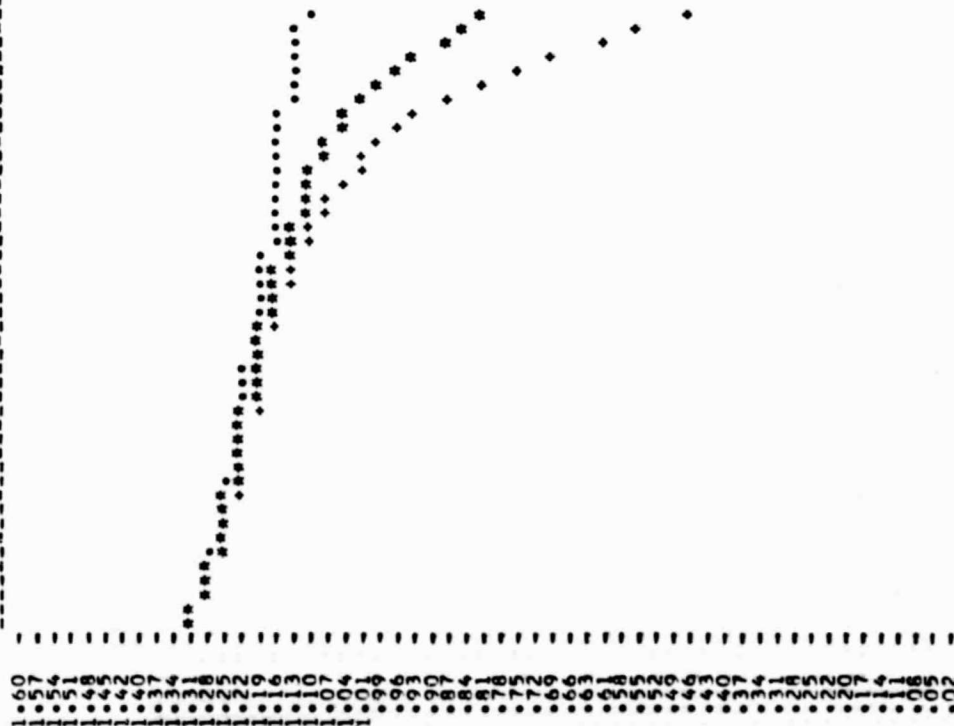
PACK NUMBER IS 202A
 SHADOW PERIOD IS 30
 CYCLE NUMBER IS 3766.
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

08 .32 .57 1.05 1.54 2.02 2.51 3.00 3.48 3.56
 1.30 1.78 2.27 2.75 3.24

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 22. 29. 37. 44. 51. 58. 65. 73. 80. 87. 94. 101. 104.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3

FIGURE 38

PACK NUMBER IS 203A
SHADOW PLOT IS 3002
CYCLE NUMBER IS 3002
DISCHARGE RATE IS 2.

AMPEFF HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

06.30.54.71.01.25.49.1.72.2.28.2.44.3.91.13.23

C 1.47
A 1.51
P 1.48
A 1.42
C 1.40
I 1.37
T 1.34
Y 1.31
C 1.28
E 1.25
L 1.22
L 1.19
V 1.16
O 1.13
L 1.10
T 1.07
A 1.04
G 1.01
E 0.98
S 0.95
C 0.92
A 0.89
L 0.86
E 0.83

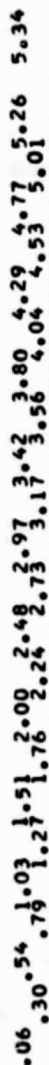
1. 8. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 87. 95. 97.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

PACK NUMBER IS 202A
SHADOW PERIOD IS 224085
CYCLE NUMBER IS 2
DISCHARGE RATE IS 2.

AMPERE HOUR OUT



CAPACITY CELL VOLTAGE SCALE

42

| CELLS INCLUDED | TIME IN MINUTES | |
|----------------|-----------------|---------|
| | V-1 | V-2 V-3 |
| 1 | 10 | 10 |
| 2 | 10 | 10 |
| 3 | 10 | 10 |
| 4 | 10 | 10 |
| 5 | 10 | 10 |
| 6 | 10 | 10 |
| 7 | 10 | 10 |
| 8 | 10 | 10 |
| 9 | 10 | 10 |
| 10 | 10 | 10 |
| 11 | 10 | 10 |
| 12 | 10 | 10 |
| 13 | 10 | 10 |
| 14 | 10 | 10 |
| 15 | 10 | 10 |
| 16 | 10 | 10 |
| 17 | 10 | 10 |
| 18 | 10 | 10 |
| 19 | 10 | 10 |
| 20 | 10 | 10 |
| 21 | 10 | 10 |
| 22 | 10 | 10 |
| 23 | 10 | 10 |
| 24 | 10 | 10 |
| 25 | 10 | 10 |
| 26 | 10 | 10 |
| 27 | 10 | 10 |
| 28 | 10 | 10 |
| 29 | 10 | 10 |
| 30 | 10 | 10 |
| 31 | 10 | 10 |
| 32 | 10 | 10 |
| 33 | 10 | 10 |
| 34 | 10 | 10 |
| 35 | 10 | 10 |
| 36 | 10 | 10 |
| 37 | 10 | 10 |
| 38 | 10 | 10 |
| 39 | 10 | 10 |
| 40 | 10 | 10 |
| 41 | 10 | 10 |
| 42 | 10 | 10 |
| 43 | 10 | 10 |
| 44 | 10 | 10 |
| 45 | 10 | 10 |
| 46 | 10 | 10 |
| 47 | 10 | 10 |
| 48 | 10 | 10 |
| 49 | 10 | 10 |
| 50 | 10 | 10 |
| 51 | 10 | 10 |
| 52 | 10 | 10 |
| 53 | 10 | 10 |
| 54 | 10 | 10 |
| 55 | 10 | 10 |
| 56 | 10 | 10 |
| 57 | 10 | 10 |
| 58 | 10 | 10 |
| 59 | 10 | 10 |
| 60 | 10 | 10 |
| 61 | 10 | 10 |
| 62 | 10 | 10 |
| 63 | 10 | 10 |
| 64 | 10 | 10 |
| 65 | 10 | 10 |
| 66 | 10 | 10 |
| 67 | 10 | 10 |
| 68 | 10 | 10 |
| 69 | 10 | 10 |
| 70 | 10 | 10 |
| 71 | 10 | 10 |
| 72 | 10 | 10 |
| 73 | 10 | 10 |
| 74 | 10 | 10 |
| 75 | 10 | 10 |
| 76 | 10 | 10 |
| 77 | 10 | 10 |
| 78 | 10 | 10 |
| 79 | 10 | 10 |
| 80 | 10 | 10 |
| 81 | 10 | 10 |
| 82 | 10 | 10 |
| 83 | 10 | 10 |
| 84 | 10 | 10 |
| 85 | 10 | 10 |
| 86 | 10 | 10 |
| 87 | 10 | 10 |
| 88 | 10 | 10 |
| 89 | 10 | 10 |
| 90 | 10 | 10 |
| 91 | 10 | 10 |
| 92 | 10 | 10 |
| 93 | 10 | 10 |
| 94 | 10 | 10 |
| 95 | 10 | 10 |
| 96 | 10 | 10 |
| 97 | 10 | 10 |
| 98 | 10 | 10 |
| 99 | 10 | 10 |
| 100 | 10 | 10 |

Figure 30

PACK NUMBER IS 202A
POST CYCLING
CYCLE NUMBER IS 4086
DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY HIGH CELL
LOW CELL
AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E

.00 .42 .91 1.39 1.88 2.36 2.84 3.32 3.78
.18 .66 1.15 1.63 2.12 2.60 3.08 3.54

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 102. 117.
95. 109.

TIME IN MINUTES
CELLS INCLUDED V-1 V-3

FIGURE 41

KEY
 * HIGH END DISCHARGE VOLTAGE
 * AVE END DISCHARGE VOLTAGE
 * LOW END DISCHARGE VOLTAGE

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 25
 AMPERE RATE 06
 SERIAL 4-41, 4-50, 6-21, 11-25, 11-30
 GENERAL ELECTRIC CELLS

PACK = 202A

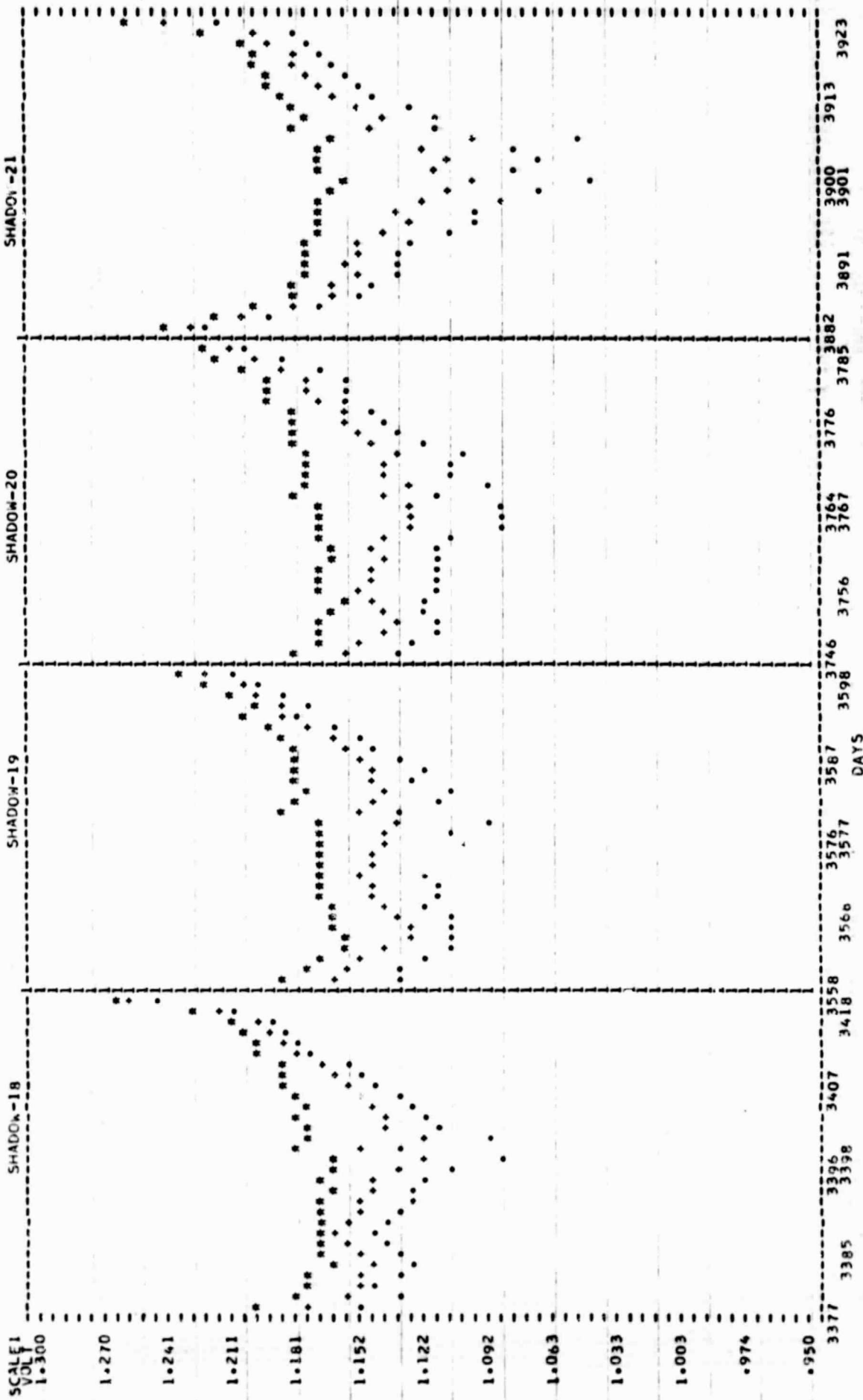


FIGURE 42

DEPTH DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 25
 AMPERE RATE 0.2
 SERIAL 4-4-60 0.6-21.11-25.11-30
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 202A

KEY
 * HIGH END DISCHARGE VOLTAGE
 • AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE

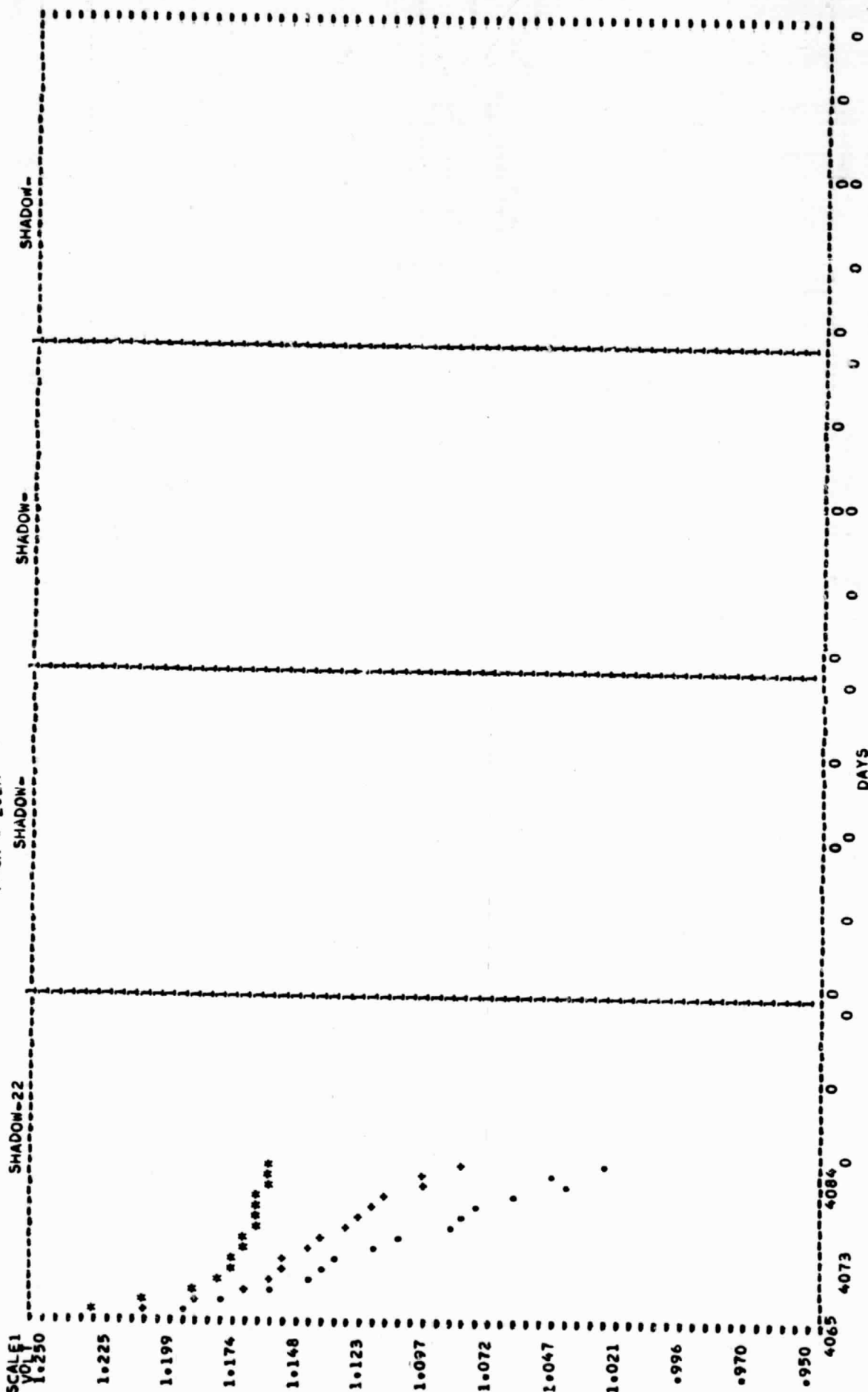


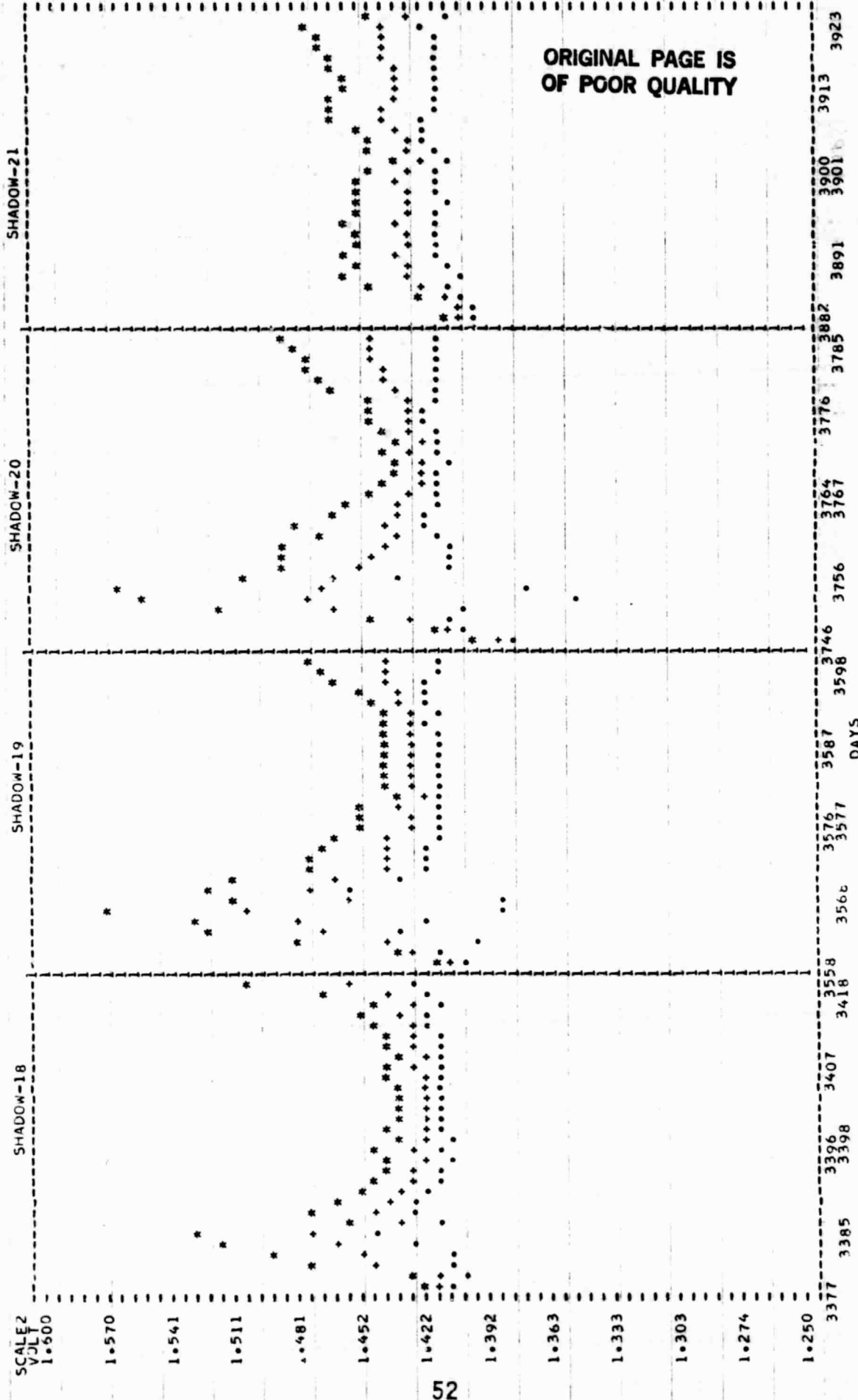
FIGURE 43

* HIGH EOC
 * AVE EOC
 * LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 202A

DEPTH DISCHARGE 40
 TEMPERATURE 25
 AMPERE RATE 02
 SERIAL 441,450,6-21,11-25,11-30
 GENERAL ELECTRIC CELLS



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OF POOR QUALITY

FIGURE 44

WQEC/C 81-120A
 DEPTH DISCHARGE 40
 TEMPERATURE 25
 AMPERE RATE 06
 SERIAL 4-41,4-50,6-21,11-25,11-30
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 202A

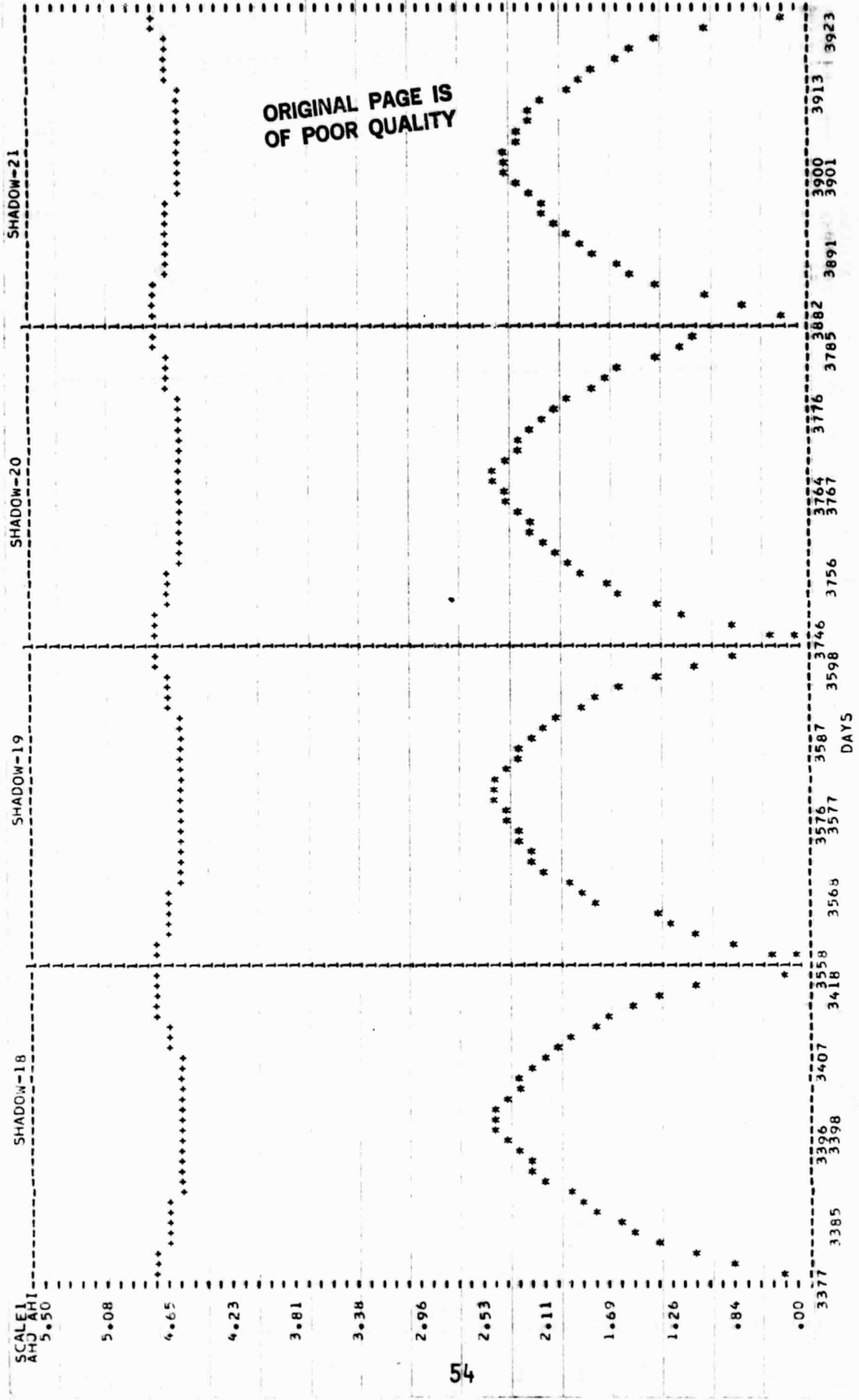


FIGURE 46

KEY λ_{HQ}
• ANY-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 202A

DEPTH DISCHARGE 40
TEMPERATURE 25
TEMPERATURE 06
SERIAL RATE 4-21-40
GENERAL ELECTRIC CELLS

SCALE 1
AND 2

SHADOW-22

SHADOW-

SHADOW-

SHADOW-

DAYS

FIGURE 47

3. Pack 203A, 5-cells

a. Cell information: (Same as Pack 201A, Section V.B.1.).

b. Parameters:

| | | | |
|------------------------|-----|--------------------------|-----|
| Depth of Discharge (%) | 40 | Discharge Current (amps) | 2.0 |
| Charge Control | CC | Temperature (°C) | 0 |
| Charge Current (amps) | .20 | Float Current (amps) | .20 |

c. Capacity Checks: (Discharge to .50 volts any cell or to a average voltage of 1.00 volts per cell, whichever occurs first.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-----------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Shadow 11 | * | | | | | 6.60 |
| Shadow 12 | | .720 | 1.173 | .916 | 1.172 | 5.25 |
| Shadow 13 | | .728 | 1.165 | .948 | 1.142 | 5.08 |
| Shadow 14 | | .801 | 1.167 | .925 | 1.086 | 4.83 |
| Shadow 15 | | .822 | 1.163 | .944 | 1.072 | 4.50 |
| Shadow 16 | | .833 | 1.147 | .951 | 1.046 | 4.53 |
| Shadow 17 | | .841 | 1.156 | .930 | 1.045 | 4.20 |
| Shadow 18 (Figure 48) | | .848 | 1.159 | .917 | 1.046 | 4.05 |
| Shadow 19 (Figure 49) | | .861 | 1.158 | .924 | 1.041 | 3.89 |
| Shadow 20 (Figure 50) | | .845 | 1.193 | .896 | 1.033 | 3.89 |
| Shadow 21 (Figure 51) | | .868 | 1.182 | .889 | 1.032 | 3.63 |
| Shadow 22 (Figure 52) | | .922 | 1.174 | .866 | 1.033 | 3.72 |
| Shadow 23 (Figure 53) | | .889 | 1.170 | .897 | 1.028 | 3.36 |
| Shadow 24 (Figure 54) | | .903 | 1.171 | .886 | 1.028 | 3.38 |
| Shadow 25 (Figure 55) | | .907 | 1.168 | .884 | 1.027 | 3.24 |
| Shadow 26 (Figure 56) | | .912 | 1.165 | .842 | 1.036 | 3.24 |
| Shadow 27 (Figure 57) | | .896 | 1.164 | .889 | 1.024 | 3.06 |

*--Removed for analysis prior to shadow 8

d. Test results during the Shadow Periods: (Figures 58 to 66)

(1) End of Discharge Voltages: The voltages during the second half of the shadow periods are higher than those during the first half because of the reconditioning effect due to the capacity checks. Cells 2 and 4 which are discharged below 1.00 volts during the capacity checks, have a greater increase in their EOD voltages following these checks.

(2) End of Charge Voltages: There is a wide divergence in these voltages throughout the shadow periods in which, during the last three shadows, was mainly due to cell 4's high cell voltage and cell 3's low voltage throughout the shadows. Cells 2 and 5 were low at the start and after 6 days would be in line with cell 4's voltage.

(3) Cell 1 was removed for analysis prior to eclipse season 8.

e. Performance during Sun Periods: The pack began test with a sun period and has now completed 27 periods. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 19 through 27.

Sun Periods

| Voltages** | 19 | | | 20 | | | 21 | | | 22 | | |
|------------|----------|----------|--|----------|----------|--|----------|----------|--|----------|----------|--|
| | Start | End | | Start | End | | Start | End | | Start | End | |
| High | 1.582(2) | 1.589(4) | | 1.530(4) | 1.567(4) | | 1.588(2) | 1.565(3) | | 1.582(2) | 1.561(4) | |
| Average | 1.547 | 1.470 | | 1.503 | 1.460 | | 1.547 | 1.483 | | 1.572 | 1.471 | |
| Low | 1.475(3) | 1.402(2) | | 1.477(3) | 1.398(2) | | 1.448(3) | 1.422(2) | | 1.442(3) | 1.417(2) | |
| Voltages | 23 | | | 24 | | | 25 | | | 26 | | |
| | Start | End | | Start | End | | Start | End | | Start | End | |
| High | 1.591(3) | 1.551(4) | | 1.599(5) | 1.562(4) | | 1.598(4) | 1.585(4) | | 1.588(2) | 1.506(4) | |
| Average | 1.546 | 1.467 | | 1.553 | 1.457 | | 1.536 | 1.455 | | 1.542 | 1.442 | |
| Low | 1.450(3) | 1.408(2) | | 1.463(3) | 1.412(2) | | 1.465(3) | 1.395(2) | | 1.426(3) | 1.401(2) | |
| Voltages | 27 | | | | | | | | | | | |
| | Start | End | | | | | | | | | | |
| High | 1.589(2) | 1.502(4) | | | | | | | | | | |
| Average | 1.540 | 1.436 | | | | | | | | | | |
| Low | 1.423(3) | 1.397(2) | | | | | | | | | | |

**--() indicates which cell

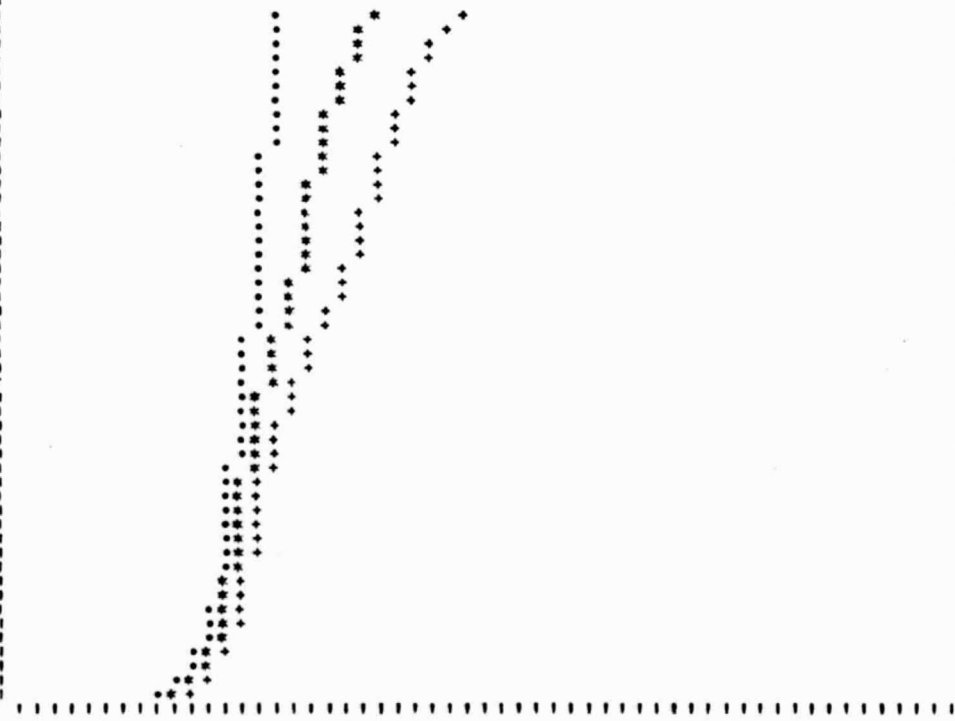
f. Cell Analysis: Visual analysis of cell 1, which completed 7 eclipse seasons, showed cell distortion due to pressure; and extreme blistering of the positive plates in which migration was greatest next to the blistered areas. Photographs were included in the 9 June 1977 report.

PACK NUMBER IS 203A
 SHADOW PERIOD IS 18
 CYCLE NUMBER IS 3397.
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 3. 16. 23. 30. 37. 44. 52. 59. 66. 73. 80. 88. 95. 103. 119.

TIME IN MINUTES
 CELLS INCLUDED V2 V3 V4 V5

FIGURE 48

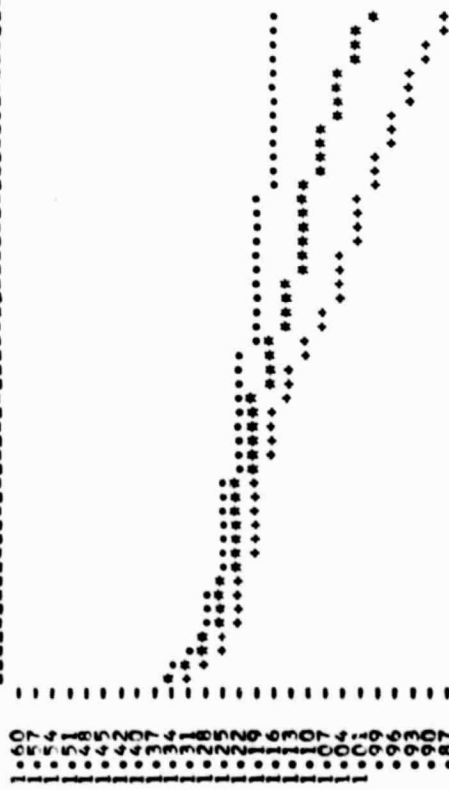
KFY HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 203A
 SHADOWN PERIOD IS 10
 CYCLE NUMBER IS 1578.
 DISCHARGE RATE IS 2.

WQEC/C 81-120A

AMPERE HOUR OUT

.19 .32 .57 .81 1.05 1.54 2.02 2.27 2.75 3.00 3.48 3.89



1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 102. 114.

TIME IN MINUTES
 CELLS INCLUDED V2 V3 V4 V5 V5

FIGURE 49

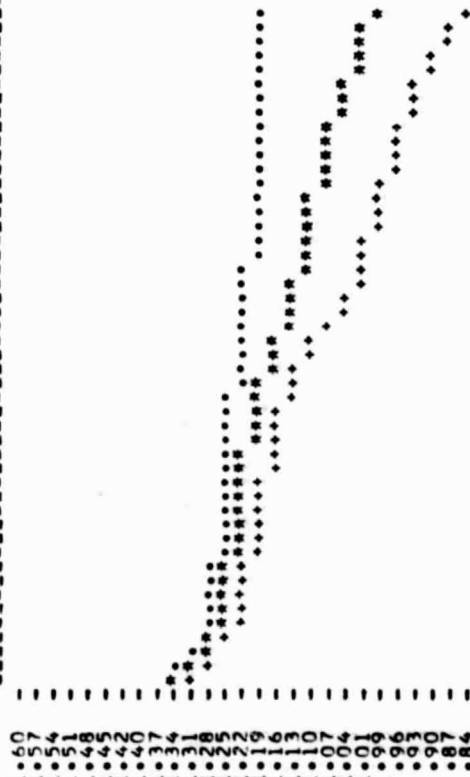
PACK NUMBER IS 2034
 SHADOW PERIOD IS 20
 CYCLE NUMBER IS 3766
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY HIGH CELL
 * LOW CELL
 * AVERAGE

08 33 57 1.06 1.54 2.03 2.51 3.00 3.49 3.89
 33 81 1.30 1.78 2.27 2.76 3.24 3.73

C
 A
 P
 A
 C
 I
 T
 Y
 C
 E
 L
 L
 V
 O
 L
 T
 A
 G
 E
 S
 C
 A
 L
 E



1. 8. 15. 23. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 114.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

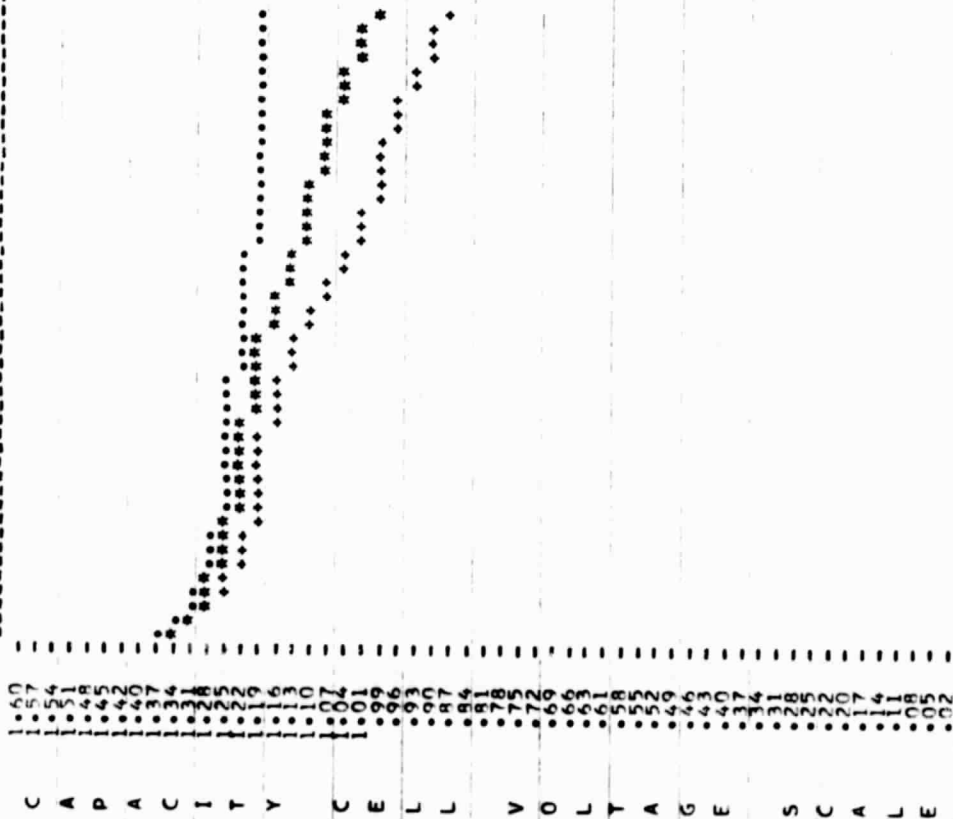
FIGURE 50

PACK NUMBER IS 203A
 SHADOW PERIOD IS 21
 CYCLE NUMBER IS 3902
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

06 .30 .55 1.03 1.52 2.00 2.49 2.98 3.46 3.62
 .30 .79 1.28 1.76 2.25 2.73 3.22



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1. 8. 15. 30. 37. 44. 51. 59. 66. 73. 80. 87. 95. 107.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 51

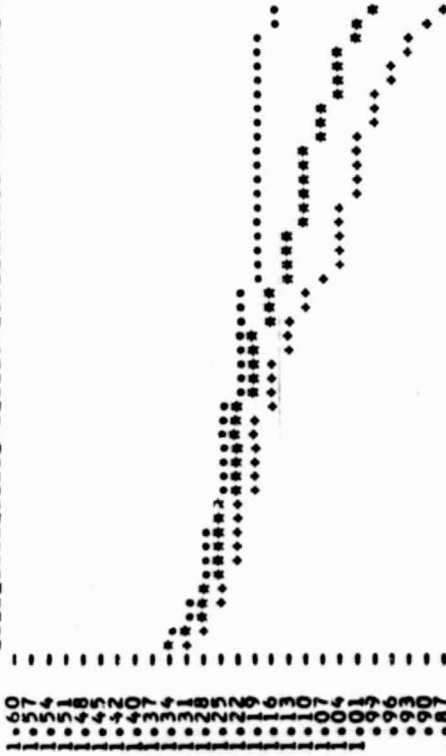
PACK NUMBER IS 203A
 SHADOW PERIOD IS 22
 CYCLE NUMBER IS 4085
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

.08 .32 .56 1.05 1.54 2.02 2.51 2.99 3.48
 1.78 2.27 2.75 3.24 3.72

KEY HIGH CELL
 LOW CELL
 AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 16. 23. 30. 37. 44. 52. 59. 66. 73. 81. 88. 95. 102. 109.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

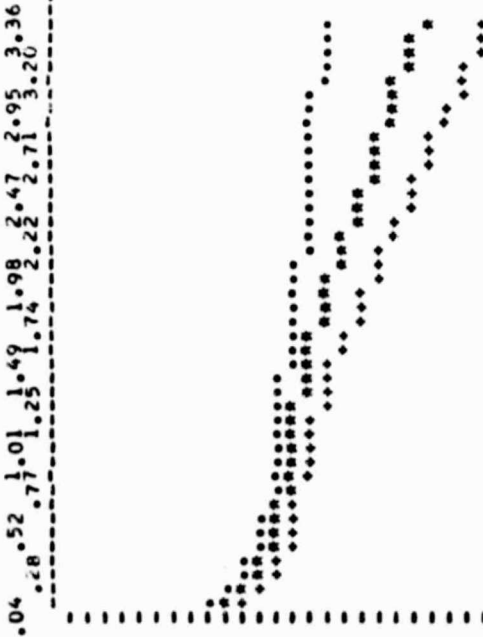
FIGURE 52

PACK NUMBER IS 203A
 SHADOWN PERIOD IS 23
 CYCLE NUMBER IS 4.65
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 16. 23. 30. 37. 44. 52. 59. 66. 73. 80. 88. 95. 100.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 53

PACK NUMBER IS 203A
 SHADOW PERIOD IS 25
 CYCLE NUMBER IS 4630
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
 HIGH CELL
 LOW CELL
 AVERAGE

04 .52 1.00 1.48 1.96 2.44 2.92 3.24
 .28 .76 1.24 1.72 2.20 2.68 3.16

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 97.

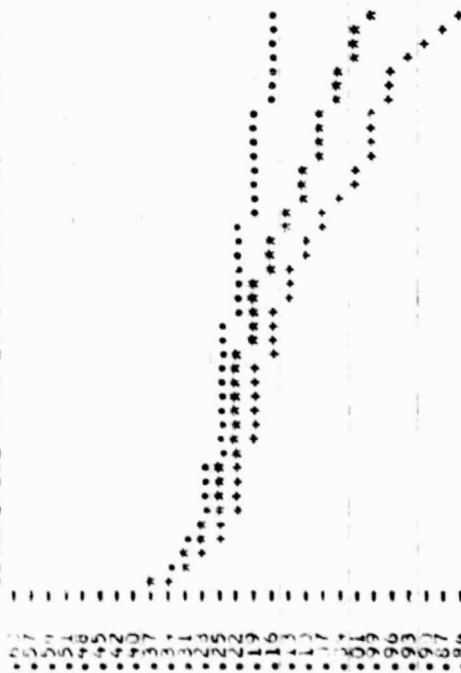
CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 55

WQEC NUMBER 15-0024
 "PERIOD" 15 26
 CYCLE NUMBER 15 4816
 DISCHARGE RATE IS 2.

AMPERE HOUR OUT

12.26 .50 .75 .99 1.47 1.72 1.96 2.44 2.92 3.24
 1.23 2.20 2.68 3.16



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1. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 97.

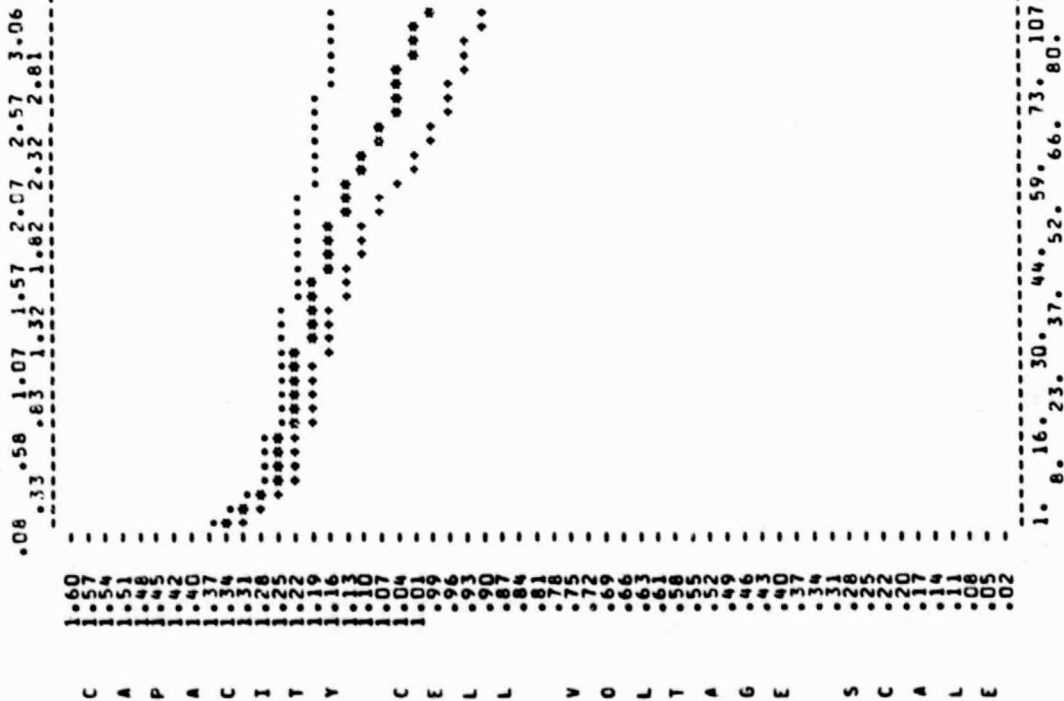
TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 56

PACK NUMBER IS 203A
SHADOW PERIOD IS 27
CYCLE NUMBER IS 4998
DISCHARGE RATE IS 2.

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE



TIME IN MINUTES
CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 57

DEPTH VOLTAGE 40
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 4-39,6-8,6-23,11-34,11-36
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

* END DISCHARGE VOLTAGE
 * AVE DISCHARGE VOLTAGE
 * LOW DISCHARGE VOLTAGE

PACK = 203A

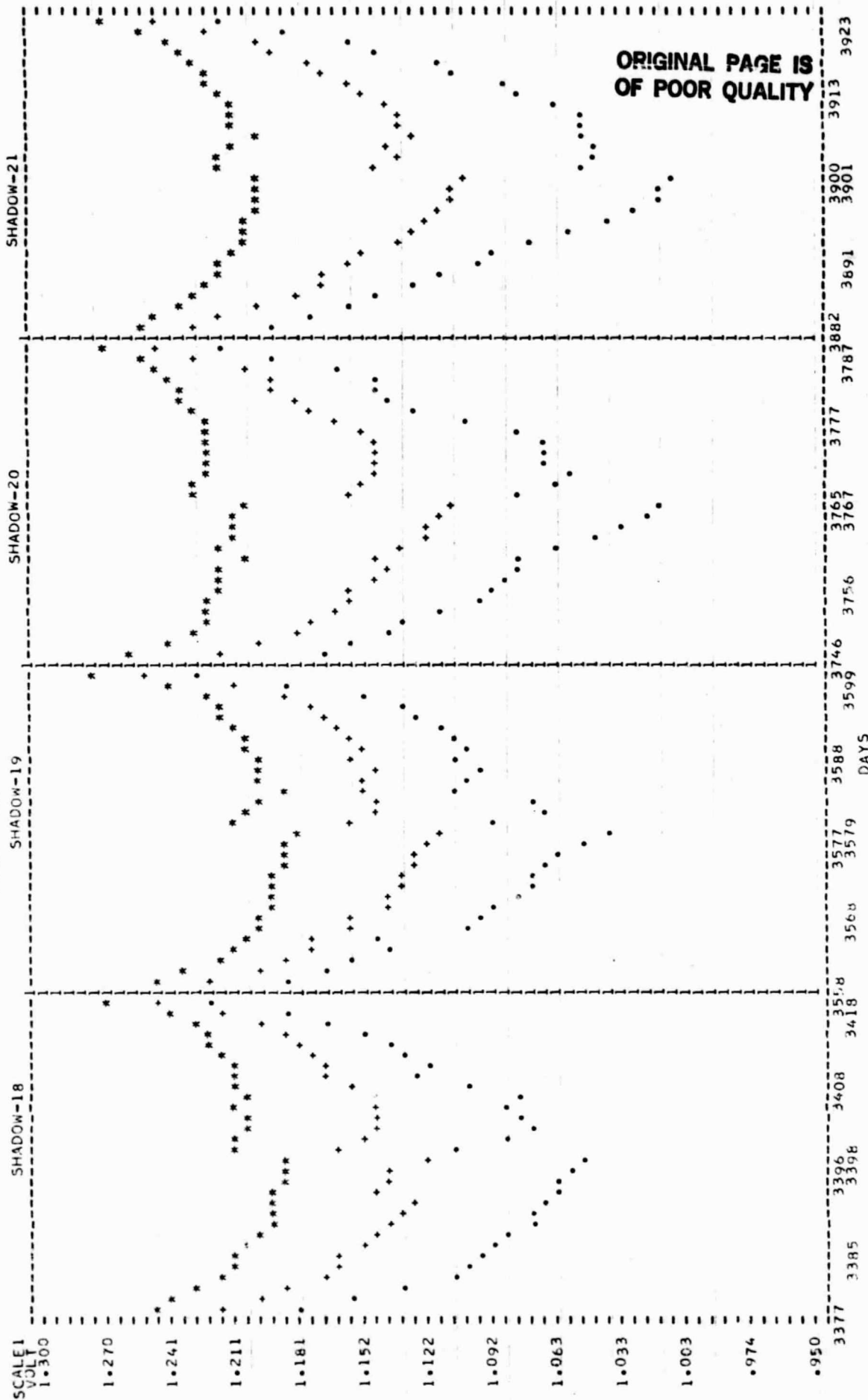


FIGURE 58

KEY
 * HIGH
 • AVE
 • LOW

END DISCHARGE VOLTAGE
 END DISCHARGE VOLTAGE
 END DISCHARGE VOLTAGE

DEPTH DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 06
 AMPERE RATE 06
 SERIAL 4-39, 6-8, 6-23, 11-34, 11-36
 GENERAL ELECTRIC CELLS

PACK = 203A

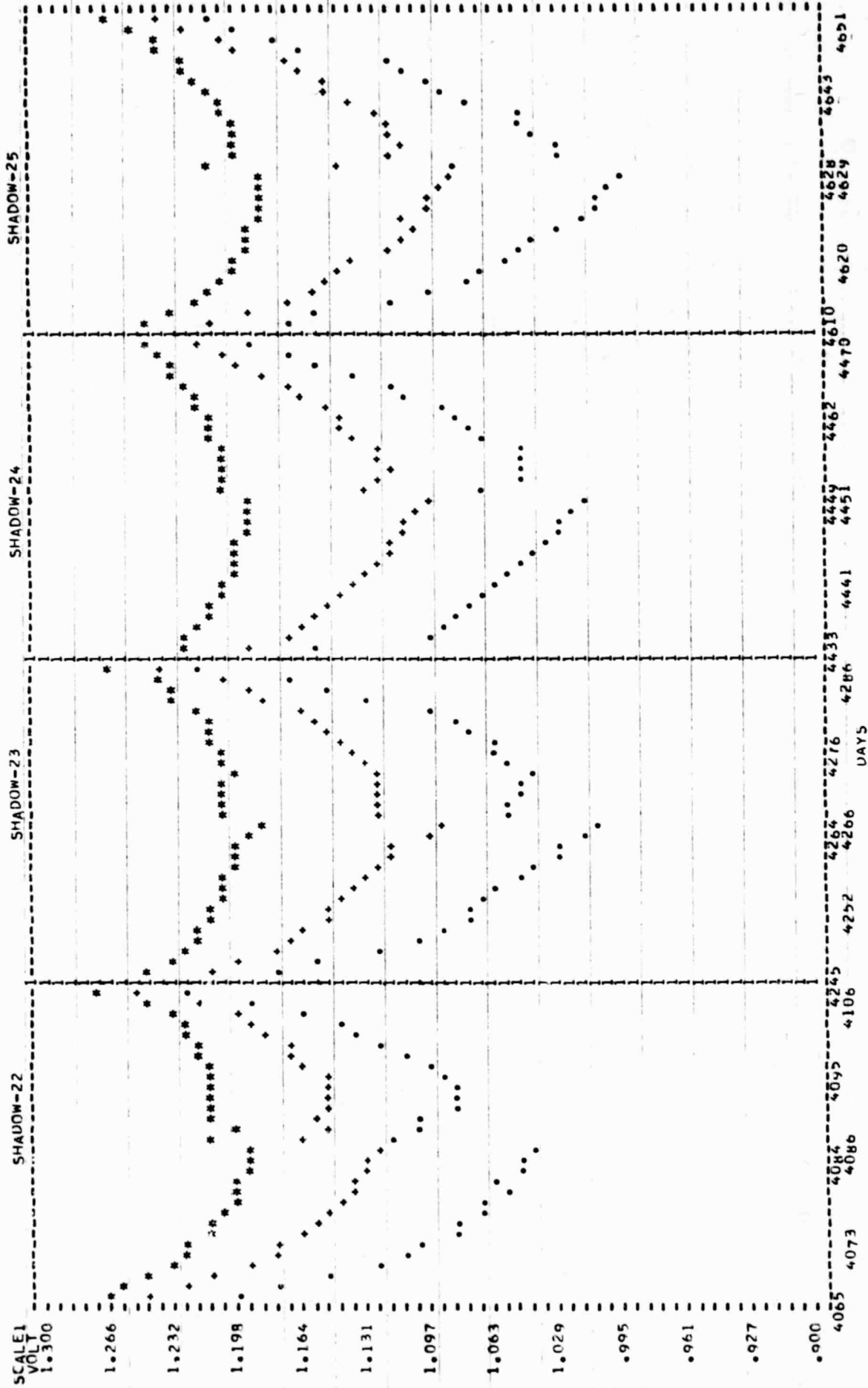


FIGURE 59

DEPTH DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 00
 SERIAL 4-39,6-8,6-23,11-34,11-36
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 203A

KEY
 * HIGH
 + AVE
 . LOW
 END DISCHARGE VOLTAGE
 END DISCHARGE VOLTAGE
 END DISCHARGE VOLTAGE

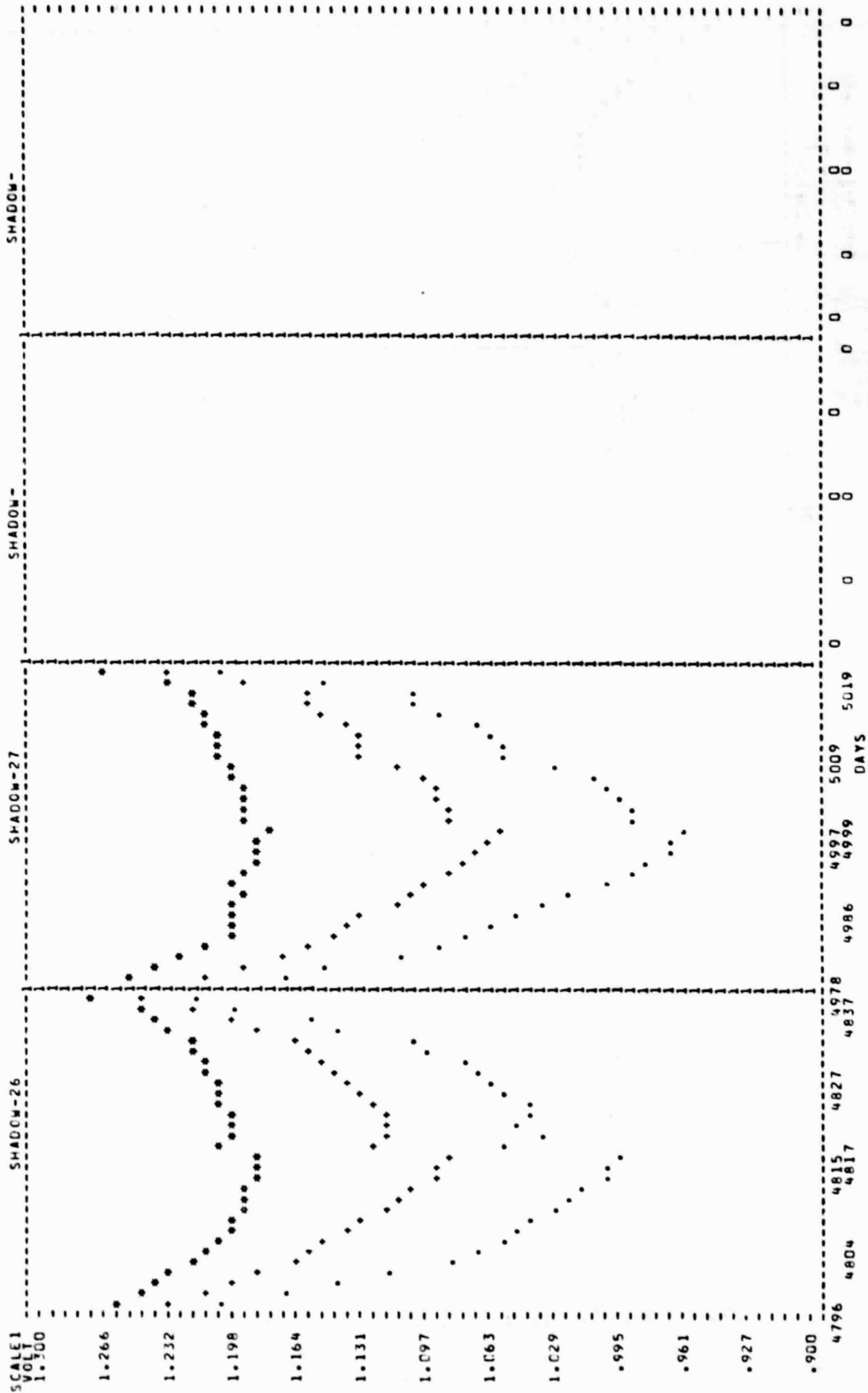


FIGURE 60

KEY
 * HIGH EOC
 + AVE EOC
 • LOW EOC

DEPTH DISCHARGE 40 MQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 4-39,6-8,6-23,11-34,11-36
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 203A

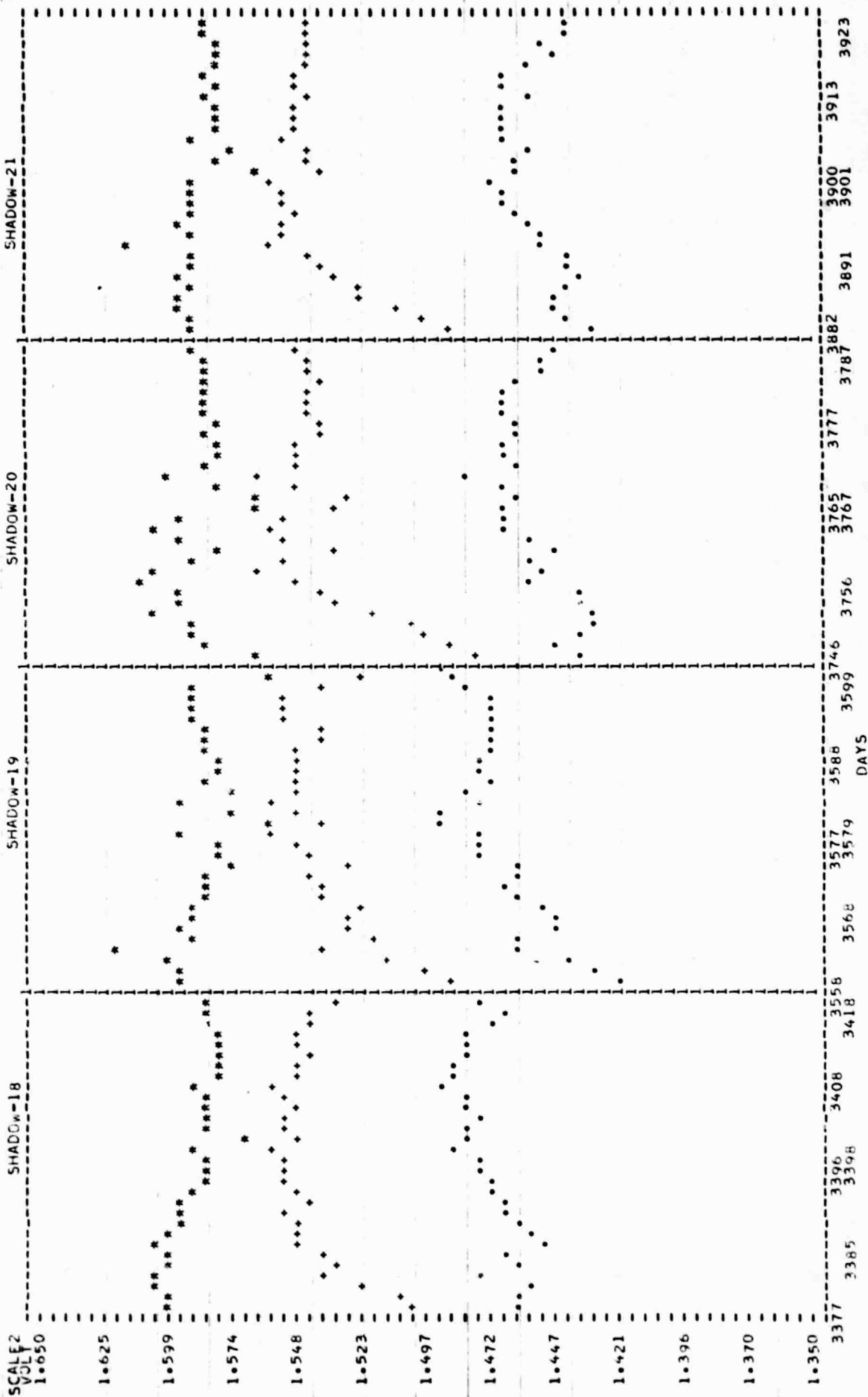


FIGURE 61

DEMI DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 4-39-6-8,6-23,11-34,11-36
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 203A

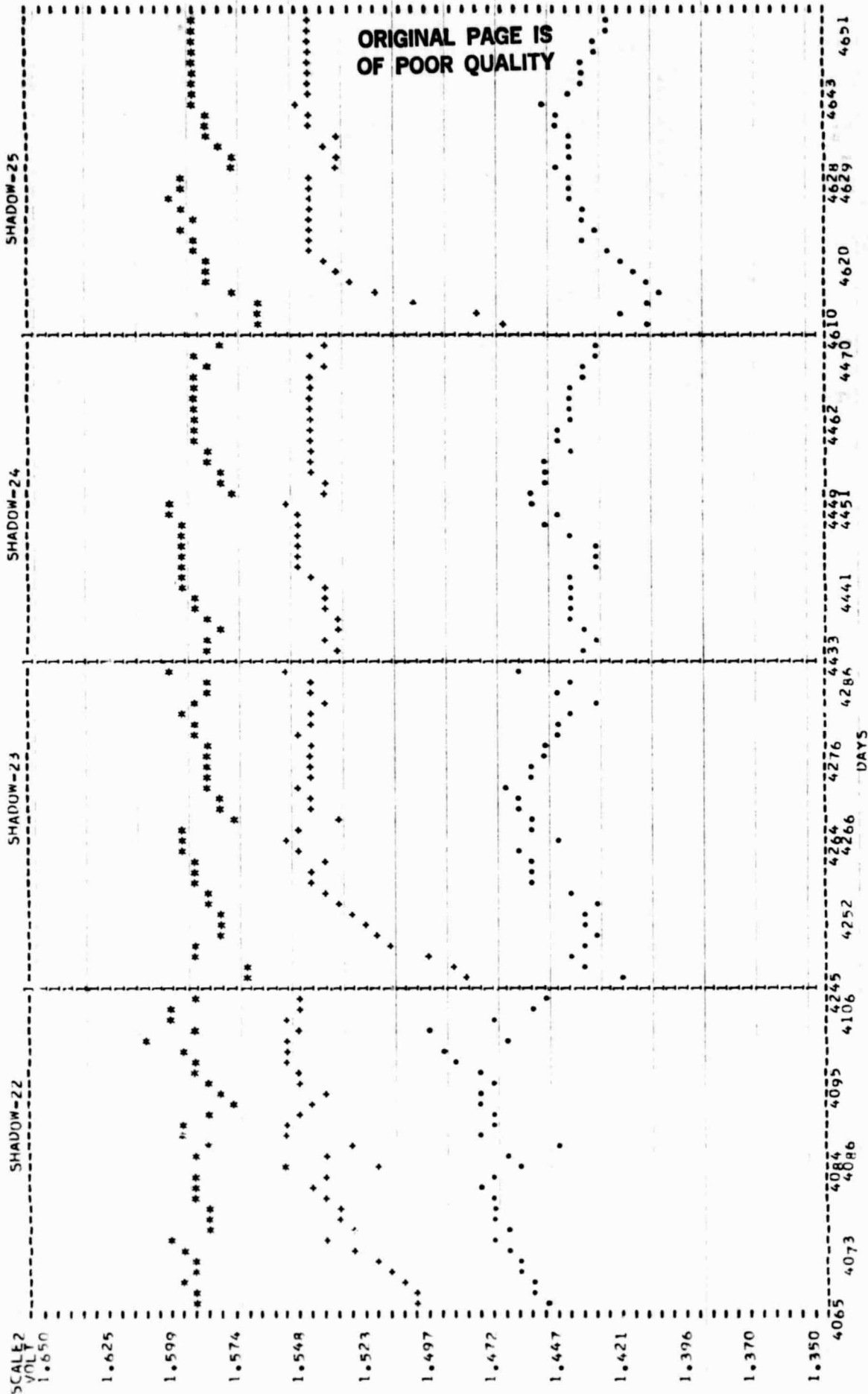


FIGURE 62

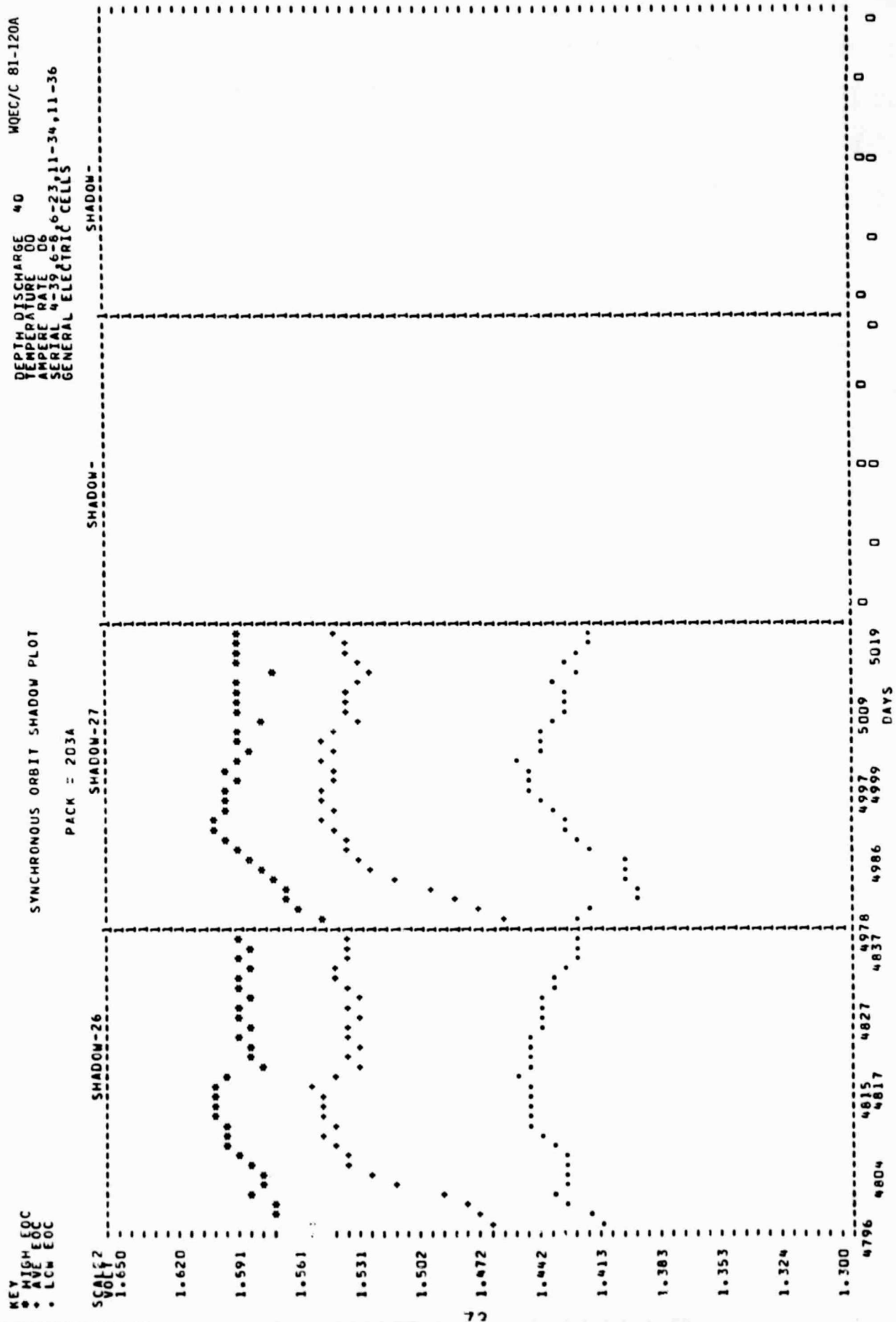


FIGURE 63

WQEC/C 81-120A
 DEPTH DISCHARGE 40
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 4-39,6-8,6-23,11-34,11-36
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 203A

SHADOW-21

SHADOW-20

SHADOW-19

SHADOW-18

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SCALE 1
 AHJ AH
 5.50

5.08

4.65

4.23

3.81

3.38

2.96

2.53

2.11

1.69

1.26

.84

.00

3377 3385 3396 3408 3418 3558 3568 3577 3588 3599 3746 3756 3765 3777 3787 3882 3891 3900 3913 3923

DAYS

FIGURE 64

KEY
 * AHO
 * AHI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 08
 SERIAL 4-39.6-8
 GENERAL ELECTRIC CELLS

PACK = 203A

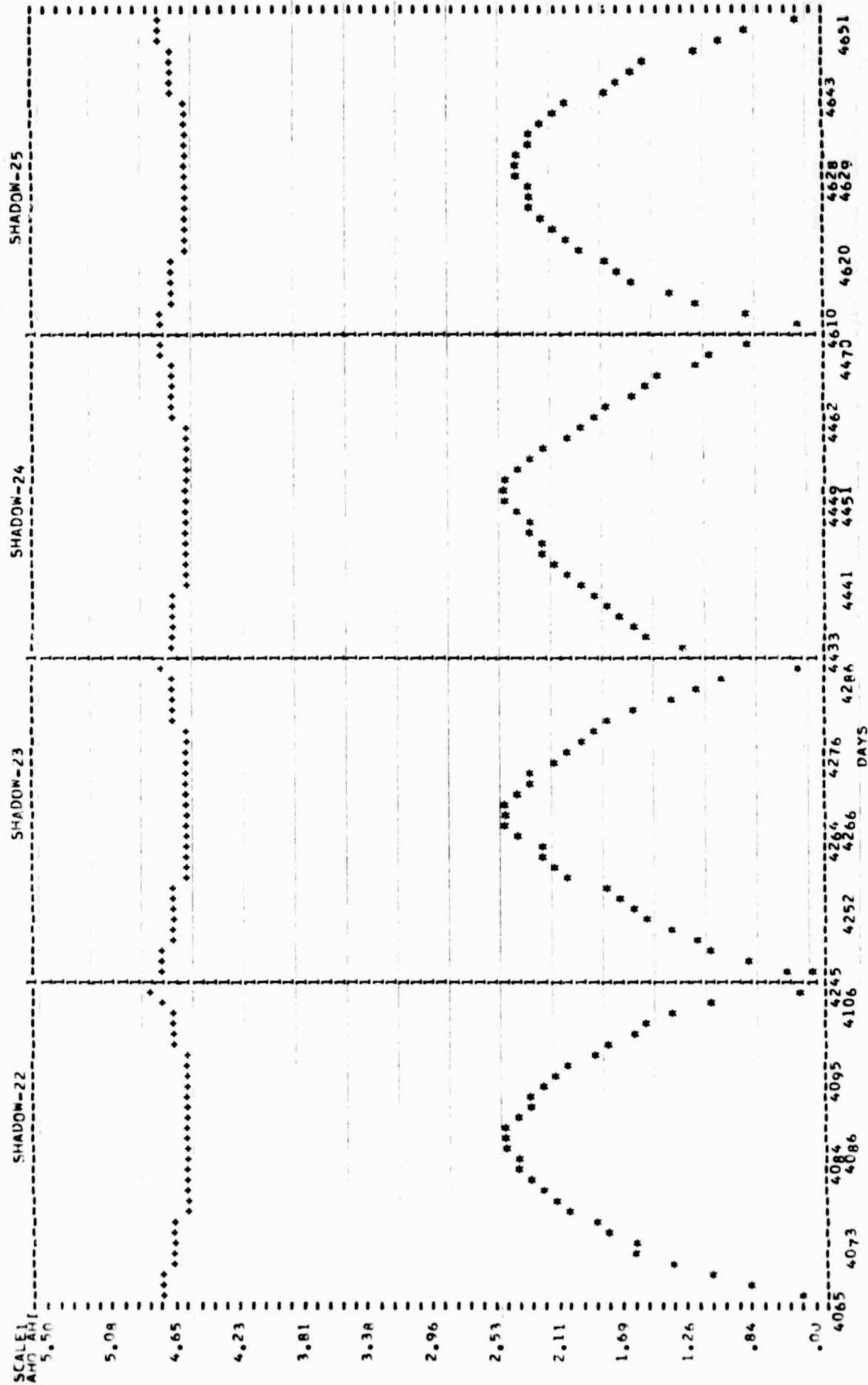


FIGURE 65

DEPTH DISCHARGE 40 WQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 4-39, 6-8, 6-23, 11-34, 11-36
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT
 PACK = 203A

KEY
 * AHO
 + AMI-TOTAL

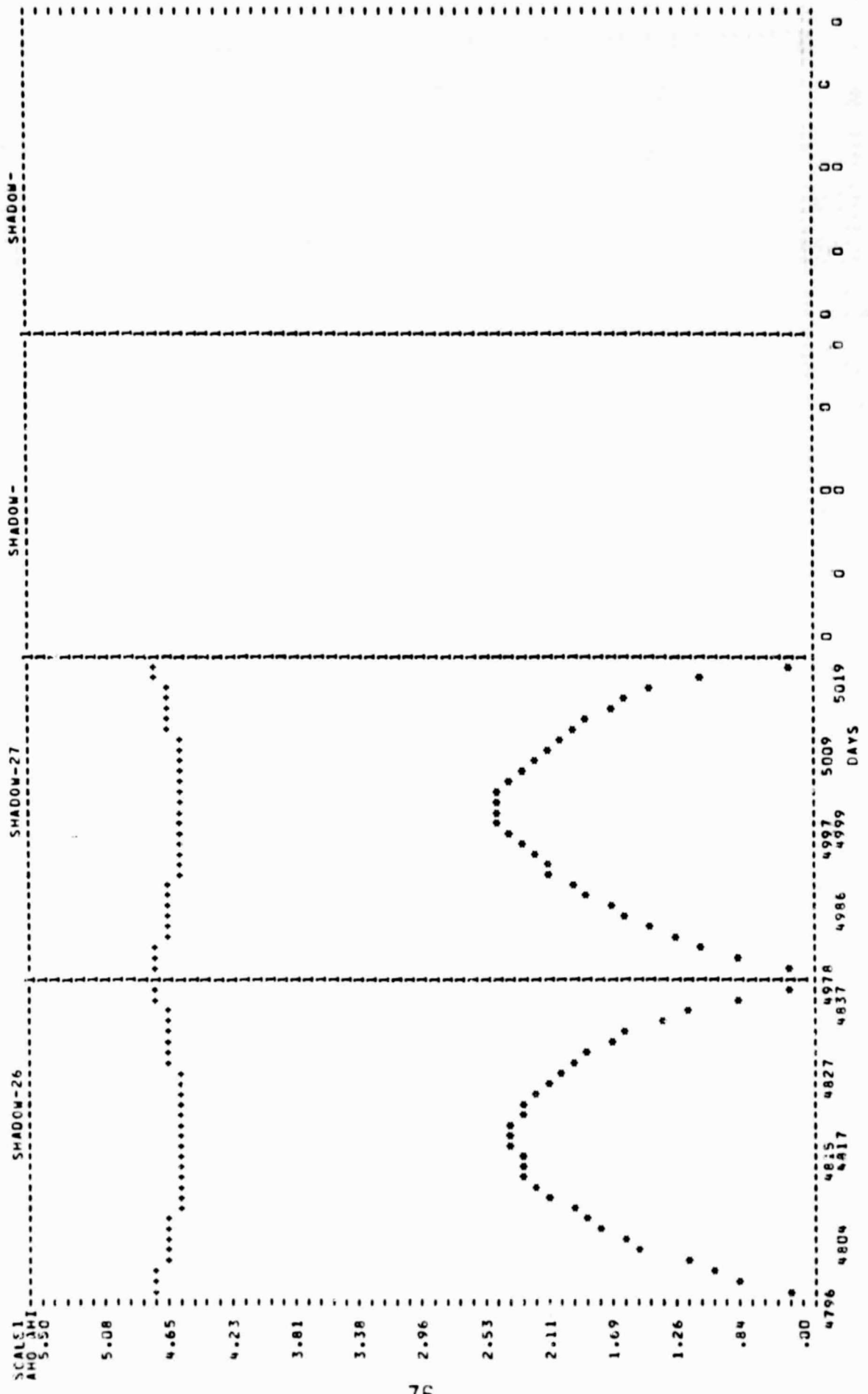


FIGURE 66

4. Pack 204A, 5-cells

a. Cell information: (Same as Pack 201A, Section V.B.1.). This pack was tested at -20°C , with a depth of discharge of 40 percent. The pack failed during the second day of eclipse season 2. The results of this pack were reported in the August 1970 report.

5. Pack 204B, 5-cells

a. Cell information: (Same as Pack 201A, Section V.B.1.). This pack was tested at -20°C , with a depth of discharge of 40 percent. The pack was discontinued following shadow period 12. Each of the three previous reports contained the results of 4 eclipse seasons.

6. Pack 205A, 5-cells

a. Cell information: (Same as Pack 201A, Section V.B.1.).

b. Parameters:

| | | | |
|------------------------|-----|--------------------------|-----|
| Depth of Discharge (%) | 60 | Discharge Current (amps) | 3.0 |
| Charge Control* | CC | Temperature (°C) | 0 |
| Charge Current (amps) | .30 | Float Current (amps) | .20 |

*Pack was on coulometer control prior to shadow 11 when its coulometer failed.

c. Capacity Checks: (Discharge to .50 volts any cell or to an average voltage of 1.00 volts per cell, whichever occurs first.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-----------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Shadow 11 | | | | | * | 5.10 |
| Shadow 12 | 1.029 | 1.049 | 1.062 | .855 | | 6.60 |
| Shadow 13 | 1.010 | 1.045 | 1.047 | .897 | | 6.24 |
| Shadow 14 | .978 | 1.039 | 1.051 | .938 | | 5.65 |
| Shadow 15 | .942 | 1.038 | 1.050 | .933 | | 5.40 |
| Shadow 16 | .962 | 1.034 | 1.034 | .978 | | 5.54 |
| Shadow 17 | .916 | 1.042 | 1.054 | .967 | | 5.20 |
| Shadow 18 (Figure 67) | .939 | 1.036 | 1.050 | .970 | | 5.00 |
| Shadow 19 (Figure 68) | .931 | 1.035 | 1.047 | .978 | | 4.92 |
| Shadow 20 (Figure 69) | .921 | 1.026 | 1.041 | .967 | | 4.92 |
| Shadow 21 (Figure 70) | .925 | 1.034 | 1.054 | .974 | | 4.67 |
| Shadow 22 (Figure 71) | .899 | 1.046 | 1.046 | .998 | | 4.92 |
| Shadow 23 (Figure 72) | .829 | 1.048 | 1.062 | .997 | | 4.22 |
| Shadow 24 (Figure 73) | .880 | 1.058 | 1.066 | .995 | | 4.44 |
| Shadow 25 (Figure 74) | .857 | 1.068 | 1.087 | .997 | | 4.10 |
| Shadow 26 (Figure 75) | .791 | 1.069 | 1.080 | 1.038 | | 4.08 |
| Shadow 27 (Figure 76) | .867 | 1.050 | 1.073 | 1.020 | | 3.93 |

*--Removed for analysis prior to shadow 8

d. Test results during the Shadow Periods: (Figures 77 to 85)

(1) End of Discharge Voltages: The reconditioning effect, due to the capacity check, is very pronounced immediately following this check; but the effect is not noticeable 1 week prior to the end of the shadow period. The greatest reconditioning effect is exhibited by cell 1 which is discharged to the lowest voltage during the capacity check.

(2) End of Charge Voltages: Historically, the voltages have shown a trend to increase in the amount of divergence from one shadow to the other; but have now maintained a somewhat constant value of divergence since shadow 14.

(3) Cell 5 was removed for analysis prior to shadow 8.

e. Performance during Sun Periods: The pack began test with a sun period and has now completed 27 periods. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 19 through 27.

Sun Periods

| Voltages** | 19 | | | 20 | | | 21 | | | 22 | | |
|------------|------------|----------|----------|----------|----------|----------|----------|----------|-----|-------|-----|-----|
| | Start | End | Start | Start | End | End | Start | End | End | Start | End | End |
| High | 1.562(5) | 1.423(3) | 1.550(4) | 1.527(4) | 1.419(3) | 1.434(3) | 1.530(4) | 1.421(3) | | | | |
| Average | 1.520 | 1.407 | 1.515 | 1.510 | 1.403 | 1.418 | 1.517 | 1.409 | | | | |
| Low | 1.500(3) | 1.394(4) | 1.482(1) | 1.485(3) | 1.390(4) | 1.406(4) | 1.491(3) | 1.397(4) | | | | |
| Voltages | 23 | | | 24 | | | 25 | | | 26 | | |
| | Start | End | Start | Start | End | End | Start | End | End | Start | End | End |
| High | 1.534(1,4) | 1.420(3) | 1.556(4) | 1.506(1) | 1.418(3) | 1.417(3) | 1.517(1) | 1.419(3) | | | | |
| Average | 1.523 | 1.408 | 1.525 | 1.497 | 1.406 | 1.409 | 1.504 | 1.411 | | | | |
| Low | 1.504(3) | 1.398(4) | 1.490(3) | 1.481(3) | 1.402(1) | 1.403(4) | 1.484(3) | 1.405(4) | | | | |
| Voltages | 27 | | | | | | | | | | | |
| | Start | End | Start | Start | End | End | Start | End | End | Start | End | End |
| High | 1.522(1) | 1.390(3) | | | | | | | | | | |
| Average | 1.496 | 1.387 | | | | | | | | | | |
| Low | 1.477(4) | 1.384(2) | | | | | | | | | | |

**--() indicates which cell

f. Cell Analysis: Visual analysis of cell 5, which completed 7 eclipse seasons, showed cell distortion due to pressure; extreme blistering of the positive plates in which migration was greatest next to the blistered areas; and loose active material because one side and the bottom of the positive plates were uncoined. Photographs were included in the 9 June 1977 report.

✓

BASED ON PERIOD 13-18
CYCLE NUMBER 15 3397.
DISCHARGE RATE IS 3.

AMPERE HOUR OUT

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TIME CELL
LOW CELL
AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E

60
57
54
51
48
45
42
40
37
34
31
28
25
22
19
16
13
10
07
04
01
99
96
93
90
87
84
81
78
75
72
69
66
63
60
57
54
51
48
45
42
40
37
34
31
28
25
22
20
17
14
11
08
05
02

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 100.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4

FIGURE 67

KEY
• HIGH CELL
♦ LOW CELL
AVERAGE

AMPERE HOUR OUT

| | | | | | | | |
|-----|------|------|------|------|------|------|------|
| .12 | .84 | 1.56 | 2.28 | 3.00 | 3.72 | 4.44 | 4.92 |
| .48 | 1.20 | 1.92 | 2.64 | 3.36 | 4.08 | 4.80 | |

1.57
1.54
1.51
1.48
1.45
1.42
1.37
1.34
1.31
1.28
1.25
1.22
1.19
1.16
1.13
1.10
1.07
1.04
1.01
0.99
0.96
0.93
0.90
0.87
0.84
0.81
0.78
0.75
0.72
0.69
0.66
0.63
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.20
0.18
0.15
0.12
0.10
0.08
0.05
0.02

**ORIGINAL PAGE IS
OF POOR QUALITY.**

| | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|-----|
| 1. | 16. | 30. | 44. | 60. | 73. | 88. | 97. |
| 8. | 23. | 37. | 52. | 66. | 80. | 95. | |

| TIME IN MINUTES | | V1 | V2 | V3 | V4 | V5 |
|-----------------|-----|-----|-----|-----|-----|-----|
| CELLS INCLUDED | | V1 | V2 | V3 | V4 | V5 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| 36 | 37 | 38 | 39 | 40 | 41 | 42 |
| 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 |
| 78 | 79 | 80 | 81 | 82 | 83 | 84 |
| 85 | 86 | 87 | 88 | 89 | 90 | 91 |
| 92 | 93 | 94 | 95 | 96 | 97 | 98 |
| 99 | 100 | 101 | 102 | 103 | 104 | 105 |
| 106 | 107 | 108 | 109 | 110 | 111 | 112 |
| 113 | 114 | 115 | 116 | 117 | 118 | 119 |
| 120 | 121 | 122 | 123 | 124 | 125 | 126 |
| 127 | 128 | 129 | 130 | 131 | 132 | 133 |
| 134 | 135 | 136 | 137 | 138 | 139 | 140 |
| 141 | 142 | 143 | 144 | 145 | 146 | 147 |
| 148 | 149 | 150 | 151 | 152 | 153 | 154 |
| 155 | 156 | 157 | 158 | 159 | 160 | 161 |
| 162 | 163 | 164 | 165 | 166 | 167 | 168 |
| 169 | 170 | 171 | 172 | 173 | 174 | 175 |
| 176 | 177 | 178 | 179 | 180 | 181 | 182 |
| 183 | 184 | 185 | 186 | 187 | 188 | 189 |
| 190 | 191 | 192 | 193 | 194 | 195 | 196 |
| 197 | 198 | 199 | 200 | 201 | 202 | 203 |
| 204 | 205 | 206 | 207 | 208 | 209 | 210 |
| 211 | 212 | 213 | 214 | 215 | 216 | 217 |
| 218 | 219 | 220 | 221 | 222 | 223 | 224 |
| 225 | 226 | 227 | 228 | 229 | 230 | 231 |
| 232 | 233 | 234 | 235 | 236 | 237 | 238 |
| 239 | 240 | 241 | 242 | 243 | 244 | 245 |
| 246 | 247 | 248 | 249 | 250 | 251 | 252 |
| 253 | 254 | 255 | 256 | 257 | 258 | 259 |
| 260 | 261 | 262 | 263 | 264 | 265 | 266 |
| 267 | 268 | 269 | 270 | 271 | 272 | 273 |
| 274 | 275 | 276 | 277 | 278 | 279 | 280 |
| 281 | 282 | 283 | 284 | 285 | 286 | 287 |
| 288 | 289 | 290 | 291 | 292 | 293 | 294 |
| 295 | 296 | 297 | 298 | 299 | 300 | 301 |
| 302 | 303 | 304 | 305 | 306 | 307 | 308 |
| 309 | 310 | 311 | 312 | 313 | 314 | 315 |
| 316 | 317 | 318 | 319 | 320 | 321 | 322 |
| 323 | 324 | 325 | 326 | 327 | 328 | 329 |
| 330 | 331 | 332 | 333 | 334 | 335 | 336 |
| 337 | 338 | 339 | 340 | 341 | 342 | 343 |
| 344 | 345 | 346 | 347 | 348 | 349 | 350 |
| 351 | 352 | 353 | 354 | 355 | 356 | 357 |
| 358 | 359 | 360 | 361 | 362 | 363 | 364 |
| 365 | 366 | 367 | 368 | 369 | 370 | 371 |
| 372 | 373 | 374 | 375 | 376 | 377 | 378 |
| 379 | 380 | 381 | 382 | 383 | 384 | 385 |
| 386 | 387 | 388 | 389 | 390 | 391 | 392 |
| 393 | 394 | 395 | 396 | 397 | 398 | 399 |
| 400 | 401 | 402 | 403 | 404 | 405 | 406 |
| 407 | 408 | | | | | |

FIGURE 68

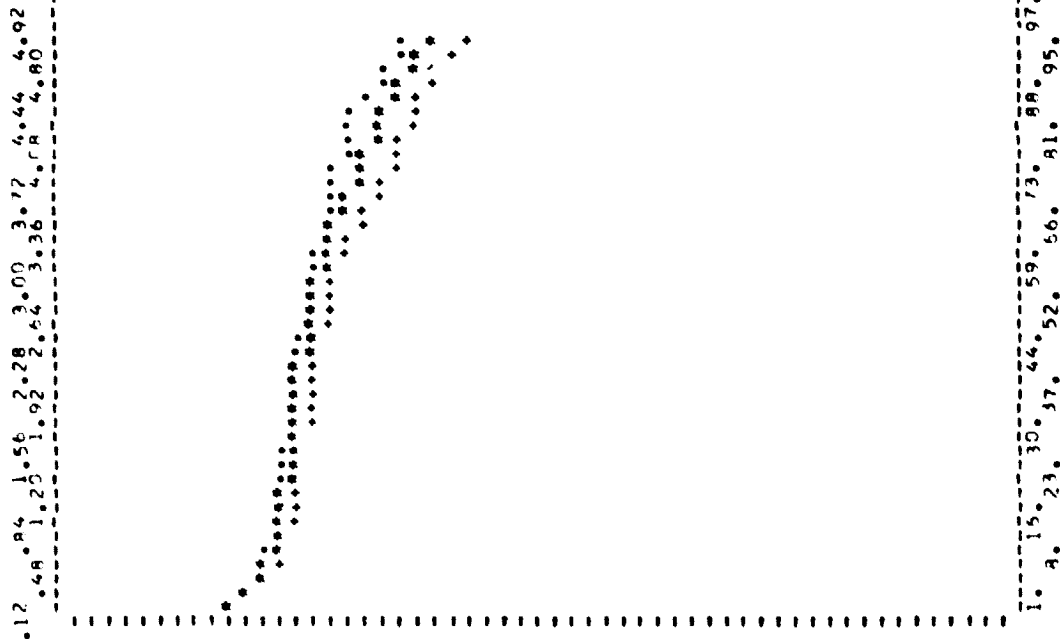
ORIGINAL PAGE IS
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BACK NUMBER IS 2056
SHADOW PERIOD IS 30
CYCLE NUMBER IS 3764.
DISCHARGE IS 3.

AMPERE HOUR OUT

• HIGH CELL
• AVERAGE

| | |
|---|-----|
| C | .67 |
| A | .57 |
| A | .51 |
| P | .45 |
| A | .42 |
| A | .40 |
| C | .37 |
| C | .34 |
| I | .31 |
| T | .29 |
| T | .25 |
| Y | .22 |
| | .19 |
| | .16 |
| | .13 |
| | .10 |
| C | .07 |
| E | .04 |
| E | .01 |
| L | .93 |
| L | .90 |
| L | .87 |
| V | .84 |
| V | .81 |
| O | .75 |
| O | .72 |
| L | .69 |
| L | .66 |
| T | .63 |
| T | .61 |
| A | .58 |
| A | .55 |
| G | .52 |
| G | .49 |
| E | .46 |
| E | .43 |
| S | .40 |
| S | .37 |
| C | .34 |
| C | .31 |
| A | .29 |
| A | .25 |
| L | .22 |
| L | .20 |
| E | .17 |
| E | .14 |
| | .11 |
| | .08 |
| | .05 |
| | .02 |
| | .00 |



TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4

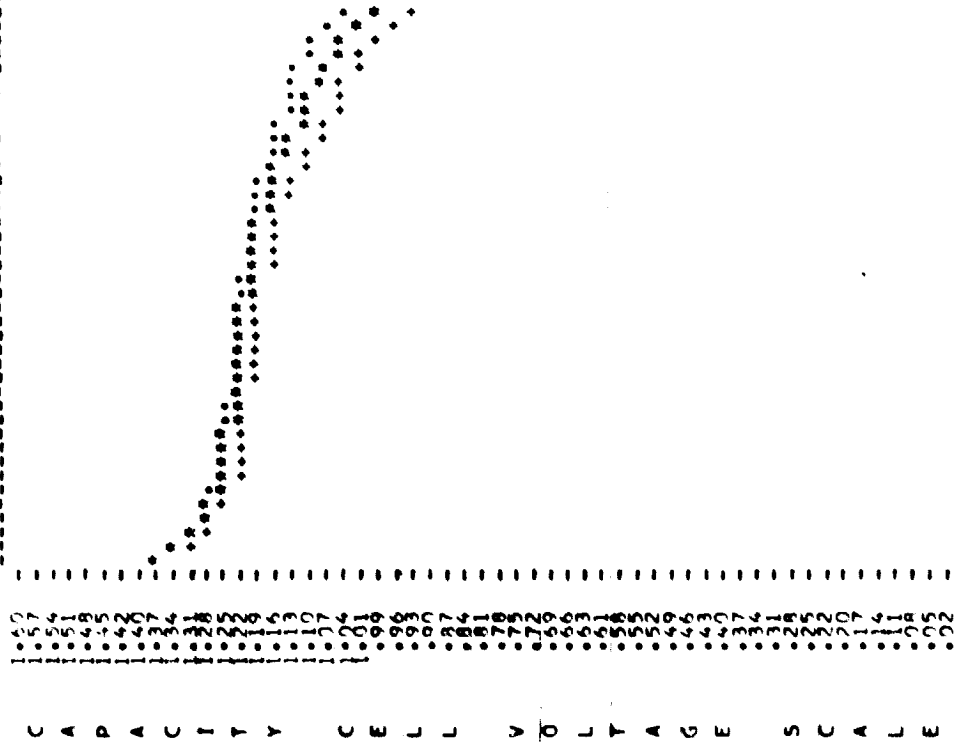
69 30051

PACK NUMBER IS 205A
SHADOW PERIOD IS 21
CYCLE NUMBER IS 3902.
DISCHARGE RATE IS 3.

AMPERE HOUR GUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

03 074 1.46 2.17 2.89 3.42 4.21
39 1.10 1.82 2.53 3.24 3.94 4.67



1. 15. 23. 30. 37. 44. 51. 59. 66. 73. 87. 95.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4

FIGURE 70

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WDEC/C 21-120A

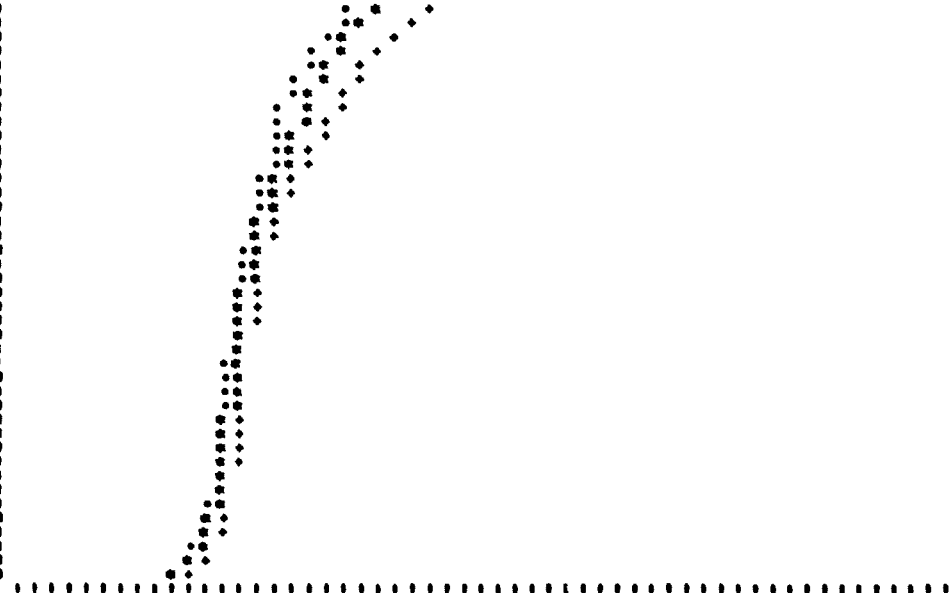
PACK NUMBER IS 205A
SHADOW PERIOD IS 22
CYCLE NUMBER IS 4085
DISCHARGE RATE IS 3.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

.12 .84 1.56 2.28 3.00 3.72 4.44 4.92
.48 1.20 1.92 2.64 3.36 4.08 4.80

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 16. 23. 30. 37. 44. 52. 59. 66. 73. 81. 88. 95. 97.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4

FIGURE 71

ORIGINAL PAGE IS
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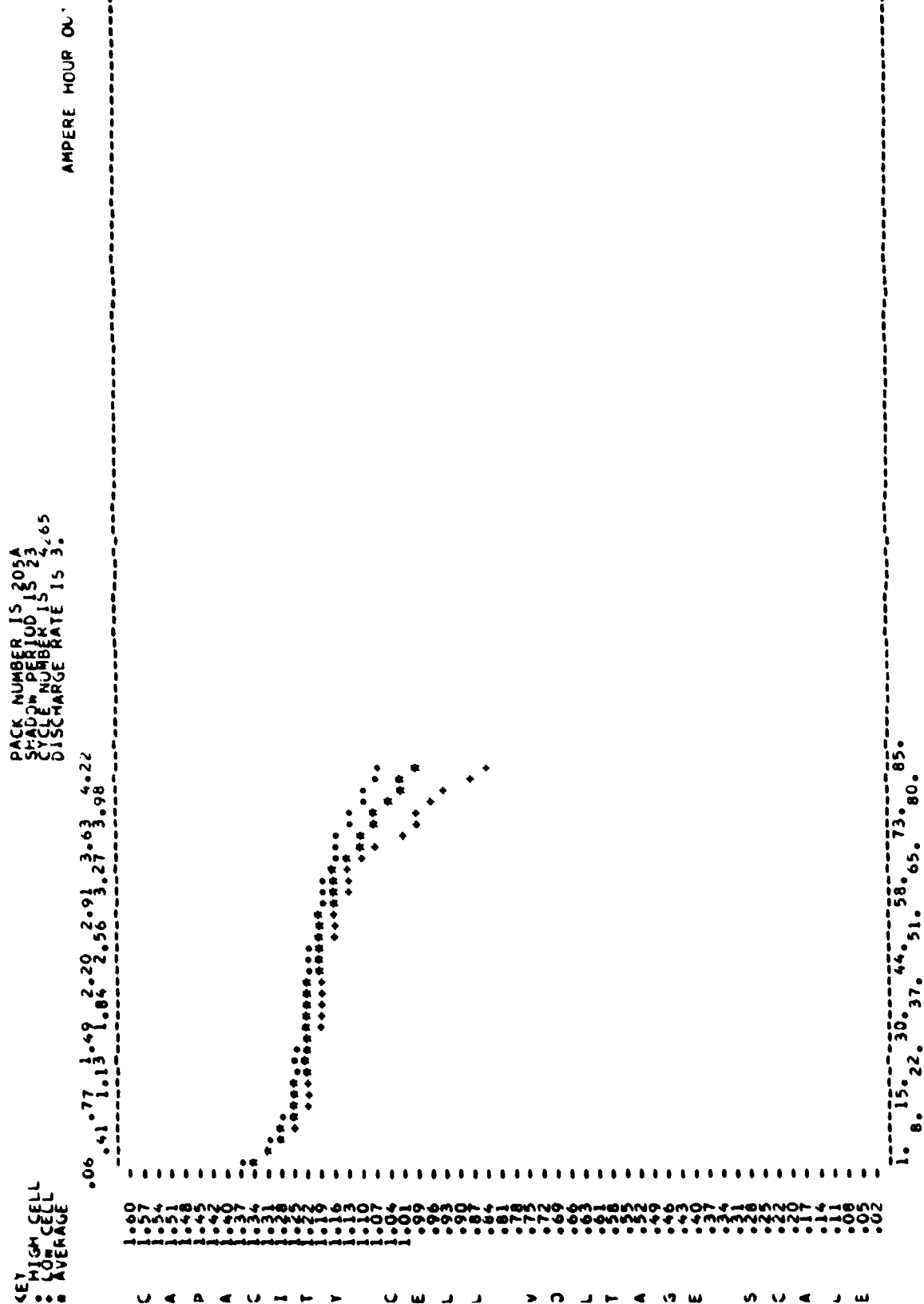
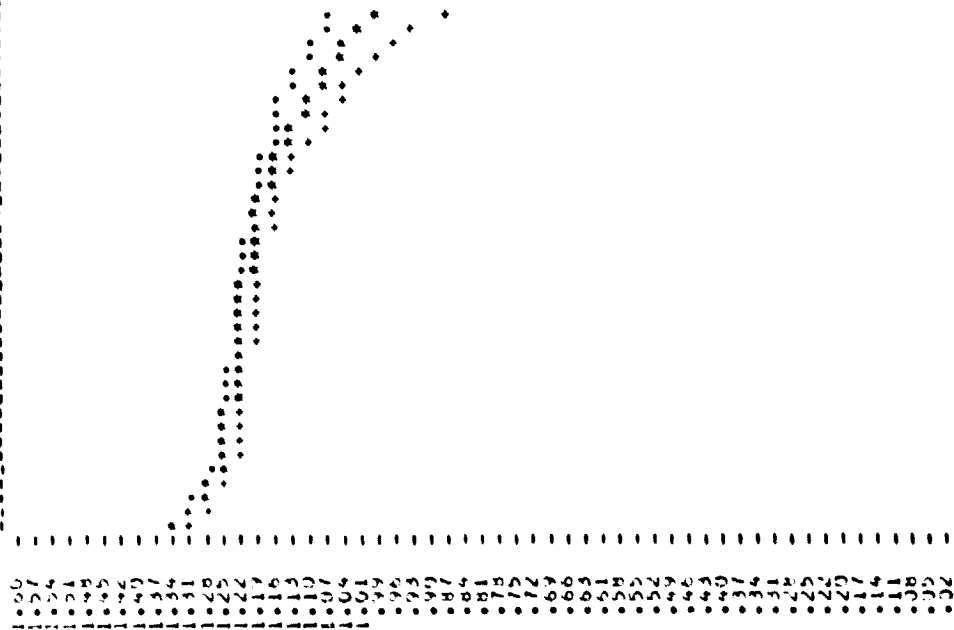
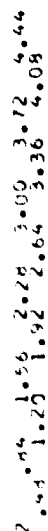


FIGURE 72

MAGNETIC PERIOD 15.2054
 SPACING PERIOD 15.24450
 CYCLE NUMBER 15
 DISCHARGE RATE 15.3.

AMPEKE HOUK OUT



| | | | | | | |
|----|-----|-----|-----|-----|-----|-----|
| 1. | 15. | 30. | 44. | 58. | 73. | 87. |
| 2. | 22. | 37. | 51. | 66. | 80. | |

| CELLS INCLUDED | TIME IN MINUTES | | |
|----------------|-----------------|-----|-----|
| | 7-1 | 7-2 | 7-3 |
| V-4 | | | |

FIGURE 73

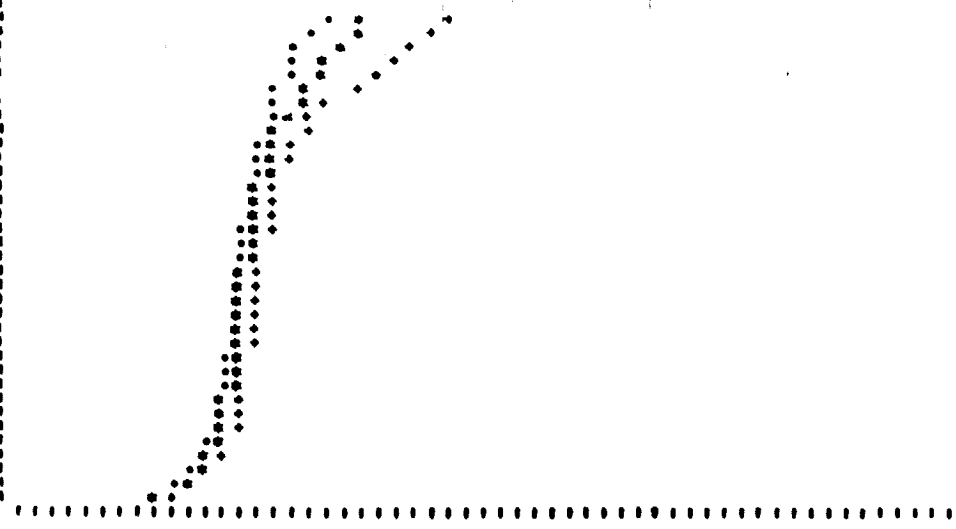
PACK NUMBER IS 205A
SHADOW PERIOD IS 25
CYCLE NUMBER IS 4430
DISCHARGE RATE IS 3.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

0.39 0.75 1.47 2.19 2.91 3.62 4.10
1.11 1.83 2.55 3.26 3.98

C
A
A
A
C
I
T
V
C
E
L
L
V
D
L
T
A
G
E
S
C
A
L
E



1. 0. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 82.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4

FIGURE 74

ORIGINAL PAGE IS
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ORIGINAL PAGE IS
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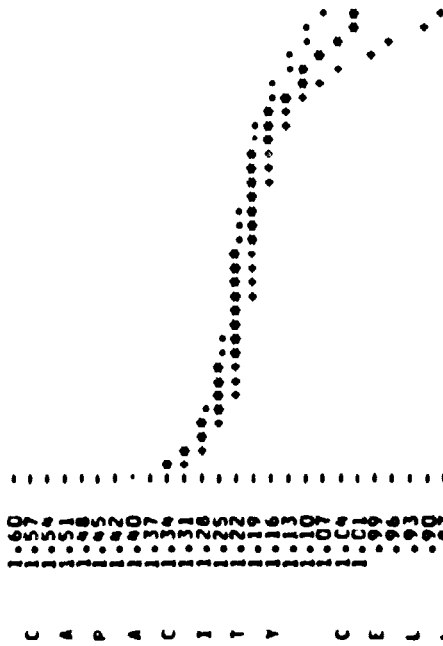
WQEC/C 81-120A

PACK NUMBER IS 205A
SHADOW PERIOD IS 27
CYCLE NUMBER IS 4998
DISCHARGE RATE IS 3.

AMPERE HOUR OUT

KEY HIGH CELL
: LCM CELL
: AVERAGE

05 01 1.53 2.25 2.57 3.69 3.93



1. 16. 23. 30. 37. 44. 52. 59. 66. 73. 78.

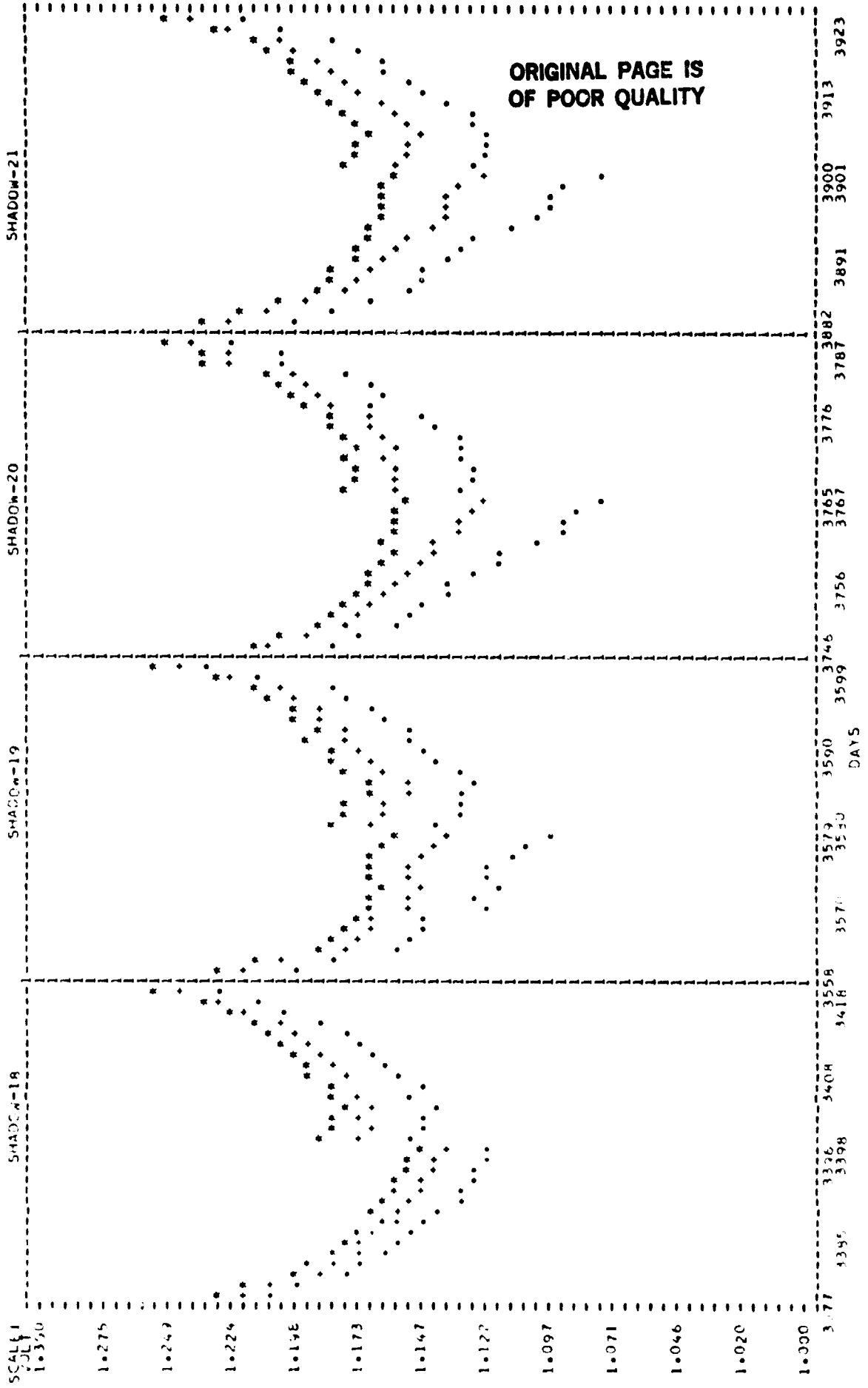
TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4

FIGURE 76

DEPTH DISCHARGE
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 11-43.11-42.11-41.11-22.6-20
 GENERAL ELECTRIC CELLS

SHADOW-18 SHADOW-19 SHADOW-20 SHADOW-21
 PACK = 205A

DISCHARGE VOLTAGE
 DISCHARGE VOLTAGE

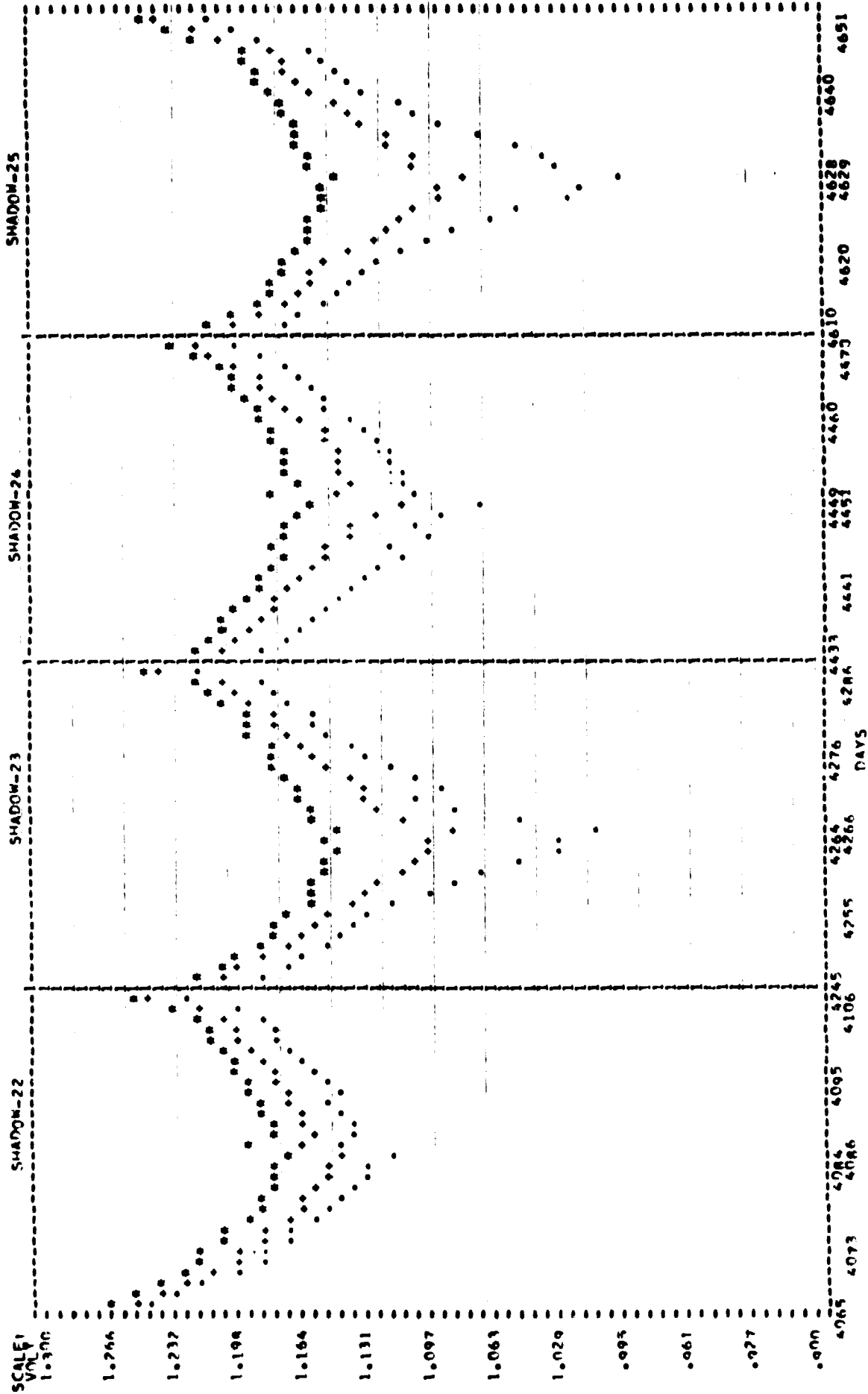


DEPTH DISCHARGE 60 MQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 11-23
 GENERAL ELECTRIC FILLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 205A

KEY
 • HIGH END DISCHARGE VOLTAGE
 • AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE



DEPTH DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 11-4311-0211-41,11-22,6-20
 GENERAL ELECTRIC CELLS

MEV HIGH END DISCHARGE VOLTAGE
 • AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 SYNCHRONOUS ORBIT SHADOW PLOT
 PACK = 2 SA

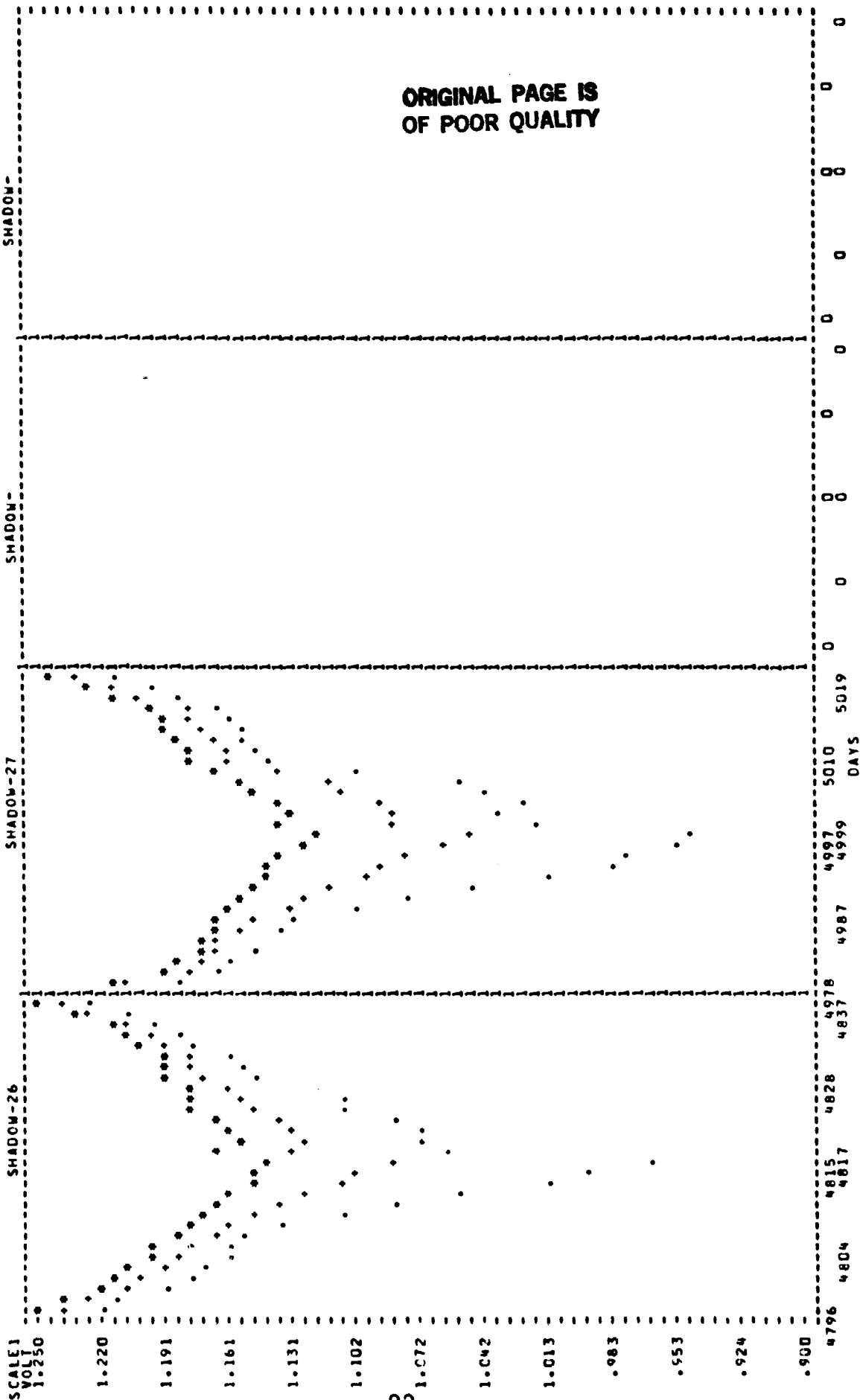


FIGURE 79

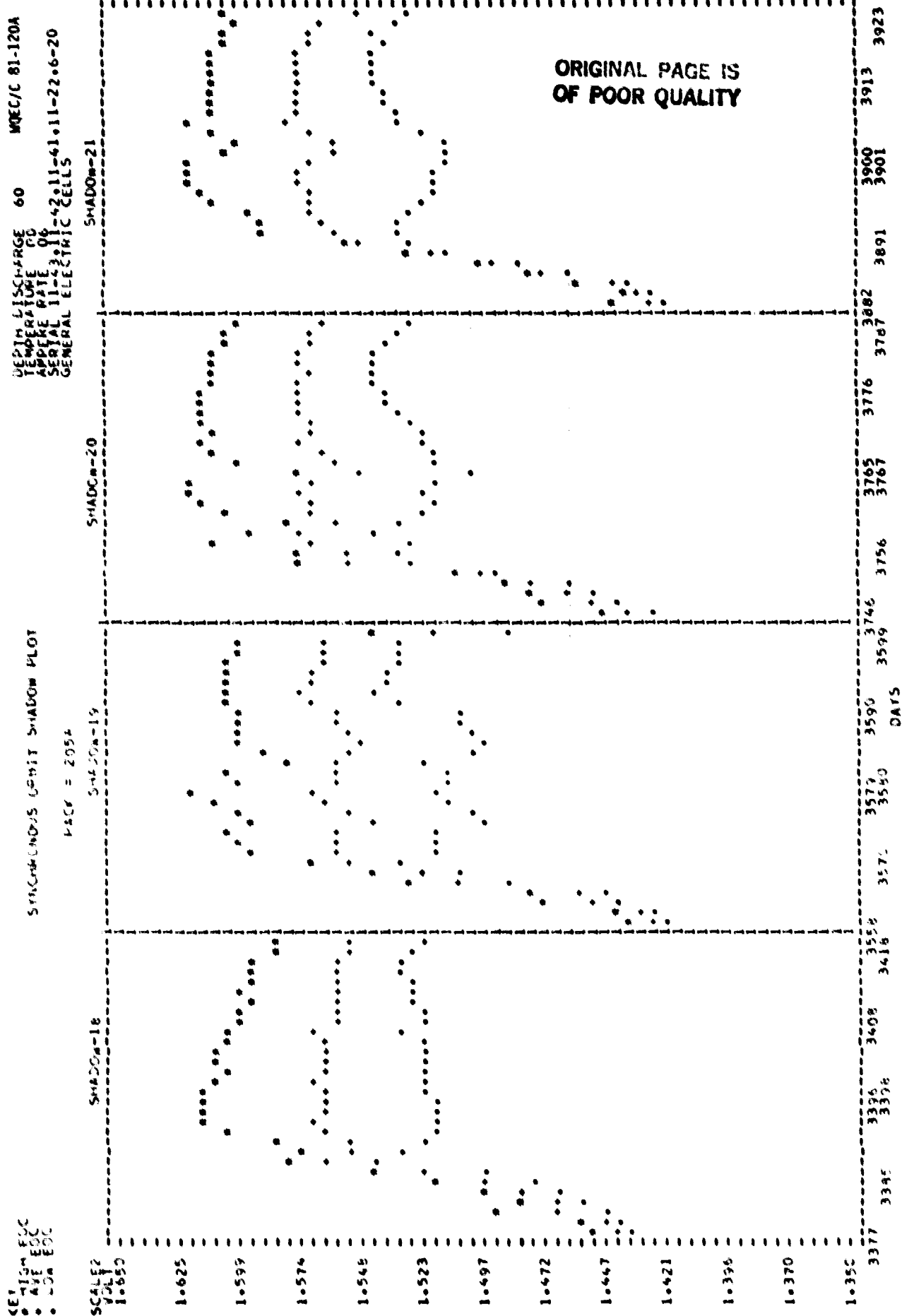


FIGURE 80

* HIGH FOC
 * AVE FOC
 * LOW FOC

SYNCHRONOUS ORBIT SHADOW PLOT
 PACK # 205A
 DEPTH DISCHARGE 60 WDEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 00
 SERVA 11-41.11-22.6-20
 GENERAL ELECTRIC FILS

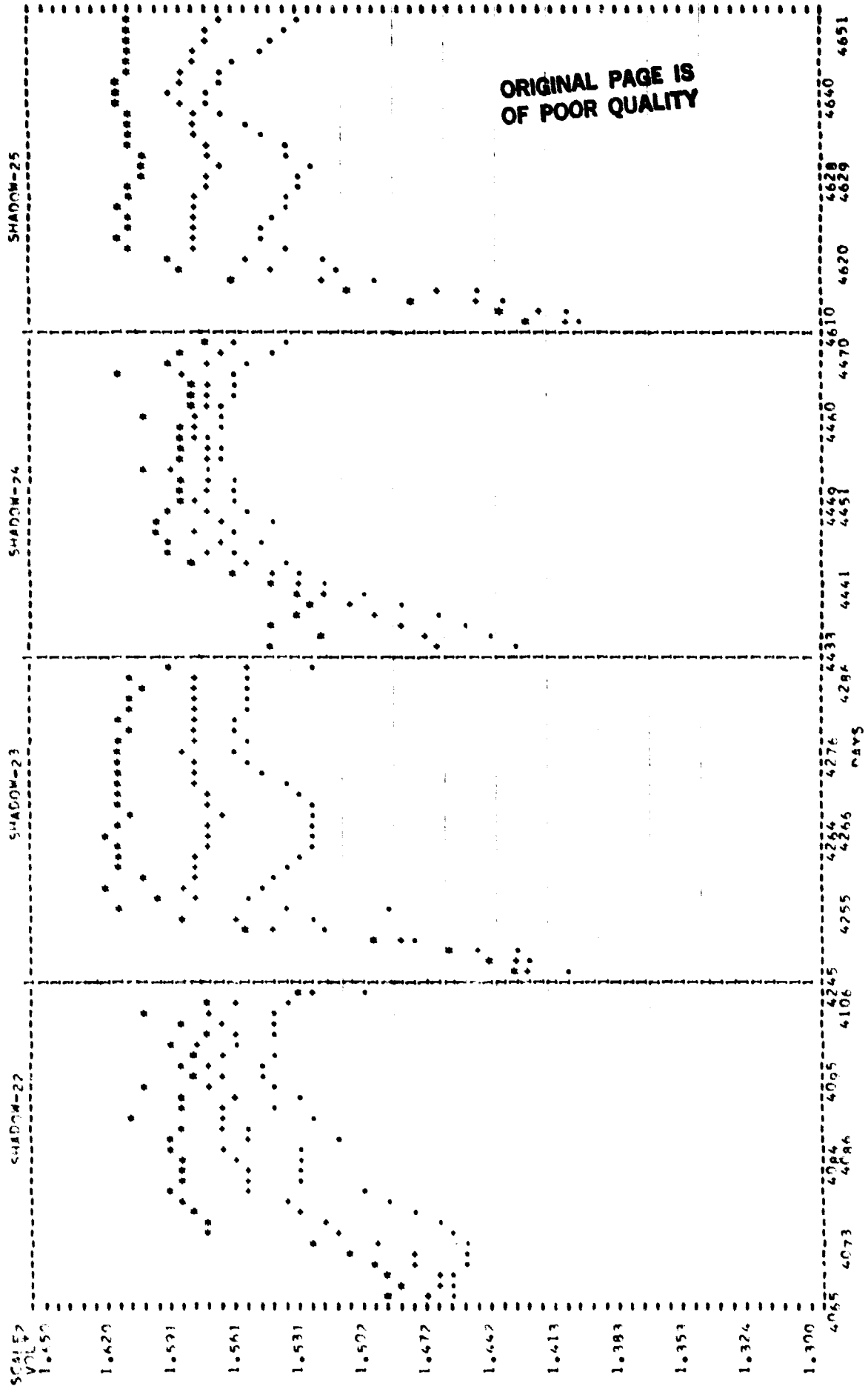


FIGURE 81

DEPTH DISCHARGE 60
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 11-4211-41.11-22.6-20
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT
 PACW = 205A

KEY
 • HIGH EOC
 • AVE EOC
 • LOW EOC

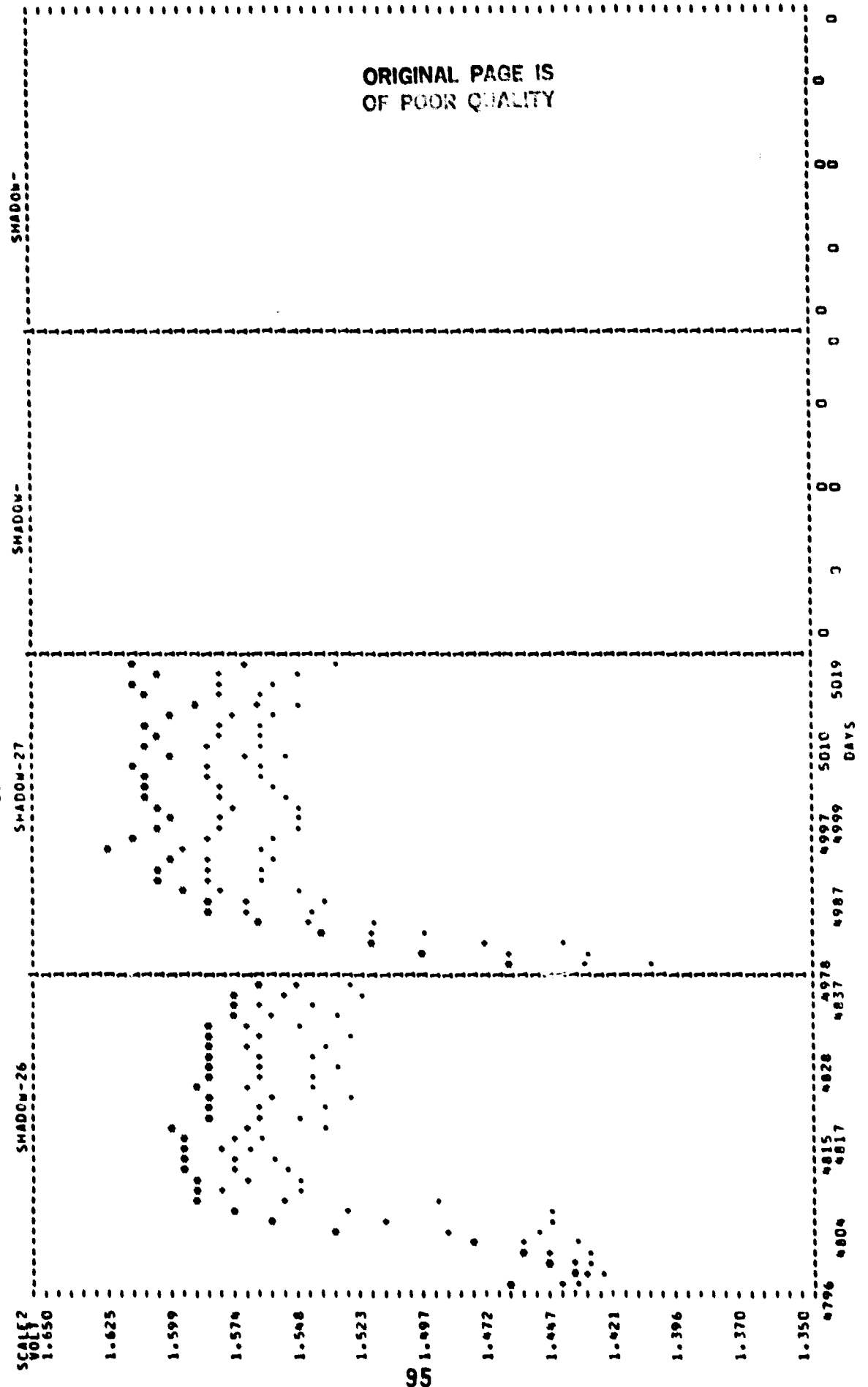


FIGURE 22

DEPTH 15 CHARGE 60 WREC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 00
 SERIAL 11-23-42 11-41.11-22.6-20
 GENERAL ELECTRIC CELLS

STAGNANTOUS GELT SHADOW PLOT

PACK = 205A

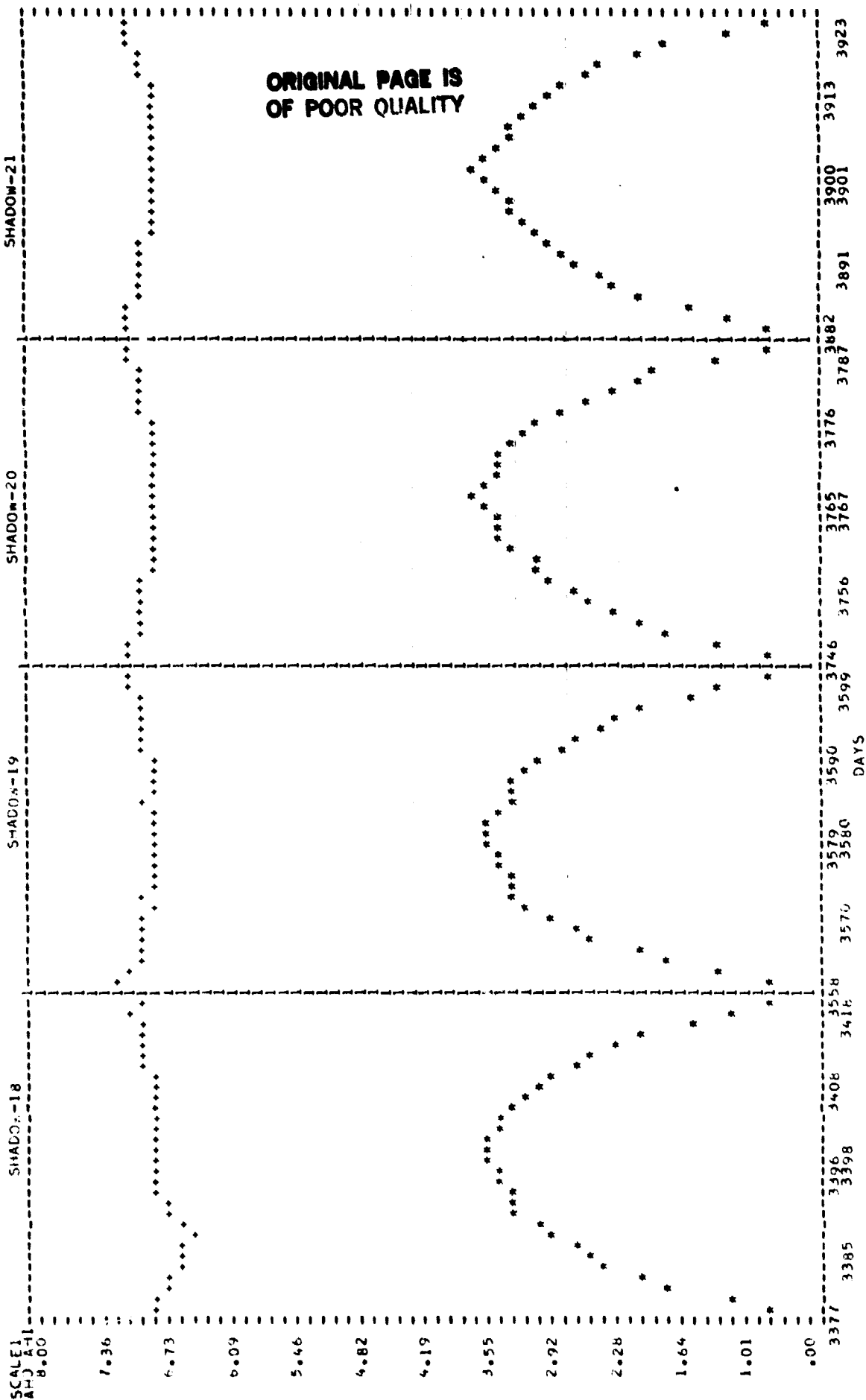


FIGURE 83

DEPTH DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 88
 AMPERE RATE 06
 SERIAL 11-43-11
 GENERAL ELEMENT 2 FILS
 11-43-11-22-6-20

SYNCHRONOUS OPBIT SHADOW PLOT
 PACK = 205A

KEY
 • AMI TOTAL

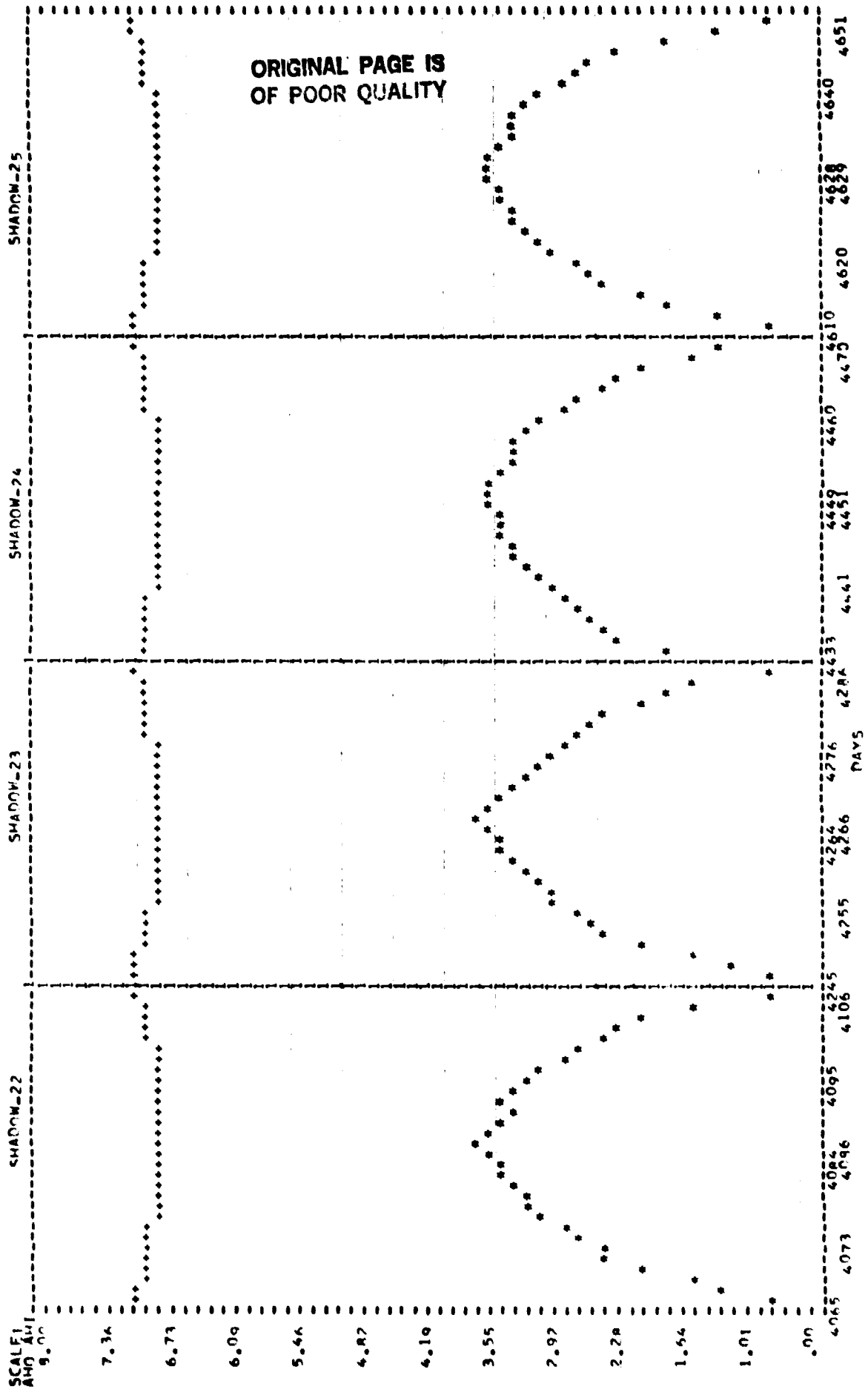


FIGURE 84

DEPTH DISCHARGE 60
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 11-43
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT
 PACK = 205A

KEY
 * AMO
 * AMI-TOTAL

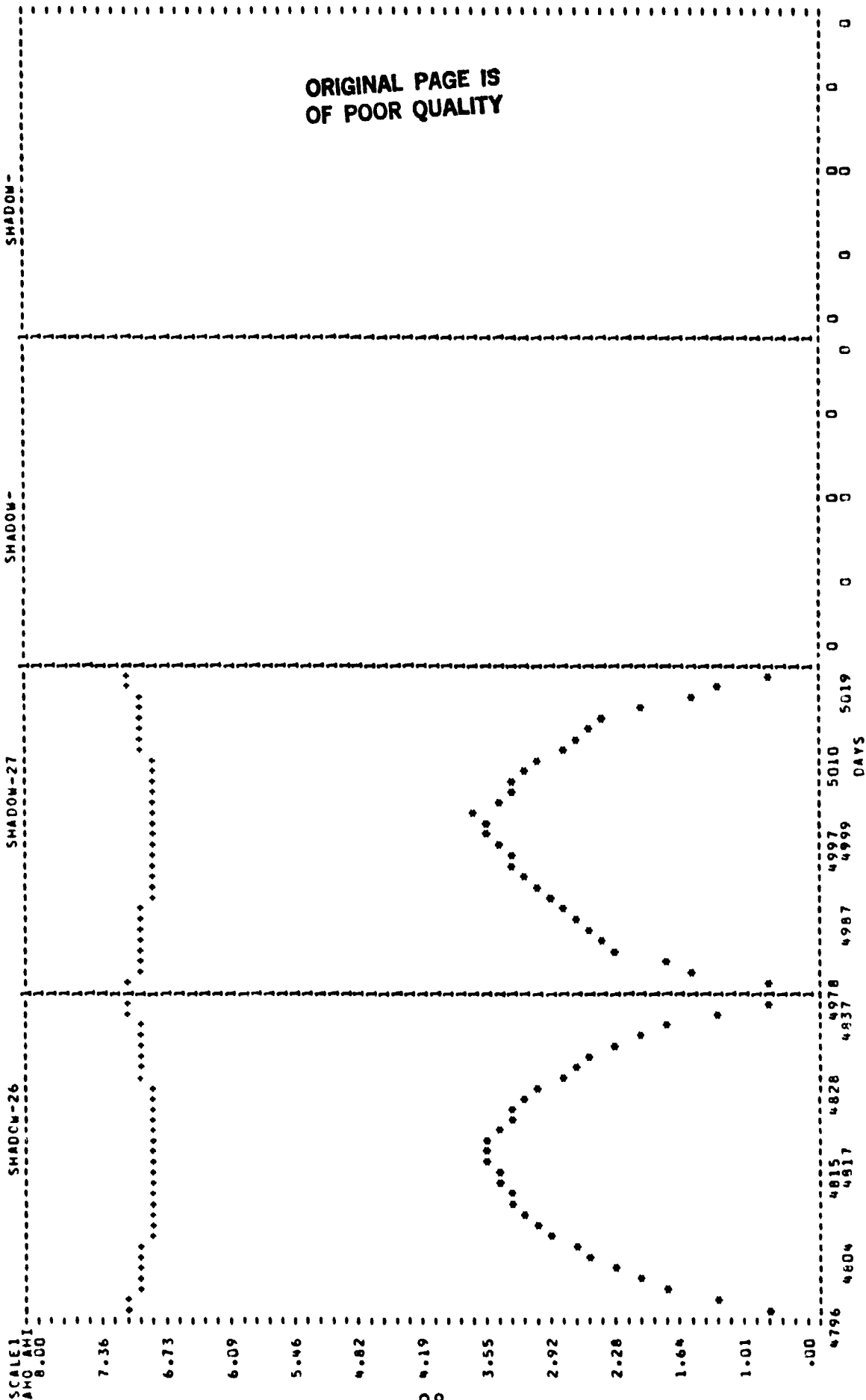


FIGURE 85

WQEC/C 81-120A

7. Pack 206A, 5-cells

a. Cell information: (Same as Pack 201A, Section V.B.1.).

b. Parameters:

| | | | |
|------------------------|-----|--------------------------|-----|
| Depth of Discharge (%) | 80 | Discharge Current (amps) | 4.0 |
| Charge Control* | CC | Temperature (°C) | 0 |
| Charge Current (amps) | .40 | Float Current (amps) | .20 |

*--Pack was on coulometer control prior to capacity check of shadow 11 when its coulometer failed.

c. Capacity Checks: (Discharge to .50 volts any cell or to an average voltage of 1.00 volts per cell, whichever occurs first.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
out |
|--------------------------|------------------|------------------|------------------|------------------|------------------|-----------|
| Shadow 11 | | | | ** | *** | 7.00 |
| Shadow 12 | .783 | 1.100 | 1.119 | | | 5.74 |
| Shadow 13 | .732 | 1.091 | 1.112 | | | 5.64 |
| Shadow 14 | .783 | 1.045 | 1.015 | | | 4.73 |
| Shadow 15 | .823 | 1.074 | 1.034 | | | 4.90 |
| Shadow 16 | .699 | 1.138 | 1.140 | | | 5.23 |
| Shadow 17 | .739 | 1.128 | 1.124 | | | 4.80 |
| Shadow 18 (Figure 86) | .727 | 1.139 | 1.137 | | | 4.51 |
| Shadow 19 (Figure 87) | .757 | 1.114 | 1.063 | | | 4.52 |
| Shadow 20 (Figure 88) | .800 | 1.120 | 1.046 | | | 4.29 |
| Shadow 21 (Figure 89) | .798 | 1.125 | 1.039 | | | 4.11 |
| Shadow 22 (Figure 90) | 5.09 | 6.34 | 7.05 | | | 4.16 |
| Post Cycling (Figure 91) | 5.67 | 6.88 | 6.77 | | | |

**--Failed, low end of discharge voltage during shadow 4 (day 1127); but was not removed from test until the middle of shadow 7.

***--Failed, shorted during shadow 11 (day 1850) prior to capacity check.

d. Test results during the Shadow Periods: (Figures 92 to 97)

(1) End of Discharge Voltages: Low values shown at the beginning of shadow 11 were because of cell 5, which shorted on day 1850. Cell 4 failed, low end of discharge voltage, on day 1127 during shadow 4. The effect of the capacity checks were similar to those of the other packs (203A and 205A) at 0°C.

(2) End of Charge Voltages: There was a wide divergence in the voltages, as was evident in the other packs at 0°C, throughout the shadow periods and the divergence was greatest at the beginning of each shadow.

(3) The pack was discontinued in the middle of shadow 22 in which each cell was discharged to .500 volts.

(4) Post Cycling: Capacities ranged from 5.67 to 6.88 ampere-hours following a .40 ampere charge for 24 hours at 0°C.

e. Performance during Sun Periods: The pack began test with a sun period and completed 22 periods. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 11 through 22.

Sun Periods

| Voltages**** | | | 11 | | 12 | | 13 | | 14 | |
|--------------|----------|----------|----------|----------|----------|----------|------------|----------|----------|-------|
| High | Start | End | Start | End | Start | End | Start | End | Start | End |
| Average | 1.517(3) | 1.485(1) | 1.516(3) | 1.472(2) | 1.493(1) | 1.470(2) | 1.520(1) | 1.478(1) | 1.491 | 1.418 |
| Low | 1.478 | 1.448 | 1.495 | 1.450 | 1.463 | 1.451 | 1.470(3) | 1.383(2) | | |
| | 1.443(2) | 1.395(3) | 1.477(2) | 1.402(3) | 1.429(3) | 1.419(3) | | | | |
| Voltages | | | 15 | | 16 | | 17 | | 18 | |
| High | Start | End | Start | End | Start | End | Start | End | Start | End |
| Average | 1.510(1) | 1.436(2) | 1.530(2) | 1.429(2) | 1.535(1) | 1.411(2) | 1.528(1,3) | 1.447(2) | 1.507 | 1.430 |
| Low | 1.478 | 1.411 | 1.513 | 1.417 | 1.502 | 1.395 | 1.472(3) | 1.416(1) | 1.466(2) | |
| | 1.431(3) | 1.389(3) | 1.480(3) | 1.402(3) | | | | | | |
| Voltages | | | 19 | | 20 | | 21 | | 22 | |
| High | Start | End | Start | End | Start | End | Start | End | Start | End |
| Average | 1.563(3) | 1.412(2) | 1.539(3) | 1.425(2) | 1.571(3) | 1.446(2) | 1.576(3) | 1.452(2) | 1.535 | 1.427 |
| Low | 1.521 | 1.397 | 1.523 | 1.410 | 1.531 | 1.421 | 1.499(2) | 1.411(1) | 1.499(2) | |
| | 1.479(2) | 1.389(1) | 1.507(2) | 1.395(1) | 1.495(2) | 1.404(1) | | | | |

****--() indicates which cell

f. Cell Analysis:

(1) Visual analysis of cell 4, which completed 6.5 shadow periods, showed extreme blistering of the positive plates in which migration was greatest next to the blistered areas; separator deterioration and dryness; and loose active material from the positive plates due to uncoining of all the plate edges. Photographs were included in the 15 October 1973 report.

(2) Following test completion, the base of cell 3's negative terminal was found to be leaking.

(3) Cell 2 was sent to GSFC for analysis and the other cells were disposed of.

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TIME IN PLANT 12
CUTS INCLUDED 12 V3

FIGURE 86

WQEC/C 81-120A

PACK NUMBER IS 206A
SHADOW PERIOD IS 19
CYCLE NUMBER IS 357a.
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

1.5 3.74 4.52
2.03

C A P A C I T Y C E L L V O L T A G E S C A L F

1.57 1.54 1.51 1.48 1.45 1.42 1.39 1.36 1.33 1.30 1.27 1.24 1.21 1.18 1.15 1.12 1.09 1.06 1.03 1.00 0.97 0.94 0.91 0.88 0.85 0.82 0.79 0.76 0.73 0.70 0.67 0.64 0.61 0.58 0.55 0.52 0.49 0.46 0.43 0.40 0.37 0.34 0.31 0.28 0.25 0.22 0.19 0.16 0.13 0.10 0.07 0.04 0.01



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1.29. 55. 67.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3

FIGURE 87

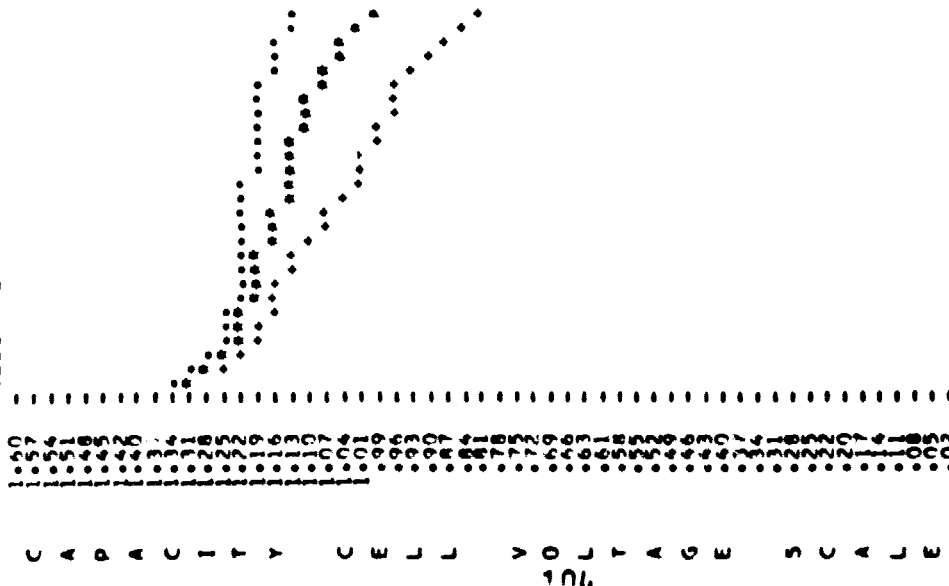
PACK NUMBER IS 206A
SHADOW PERIOD IS 30
CYCLE NUMBER IS 3766.
DISCHARGE RATE IS 4.

AMPERE HOUR UNIT

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KEY HIGH CELL
• LOW CELL
• AVERAGE

1. 1.11 2.07 3.02 3.07 4.29
64 1.59 2.54 3.50



TIME IN MINUTES V-1 V-2 V-3
CELLS INCLUDED

FIGURE 88

WQEC/C 81-120A

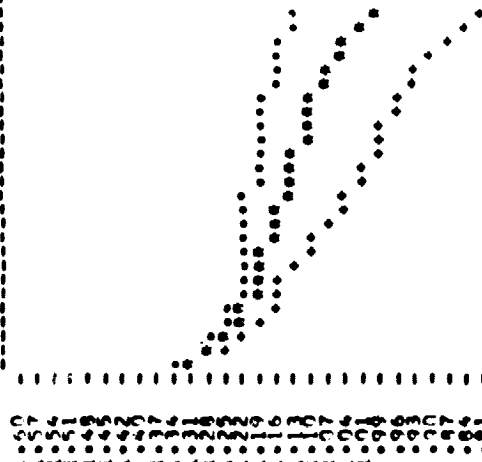
PACK NUMBER IS 206A
SHADOW PERIOD IS 21
CYCLE NUMBER IS 3907
RECHARGE RATE IS 2.

AMPERE HOUR GUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

1. 63 1.10 2.05 3.00 3.47 3.95 4.11

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 9. 16. 23. 31. 37. 45. 52. 59. 61.

TIME IN MINUTES V-1 V-2 V-3
CELLS INCLUDED V-1

FIGURE 89

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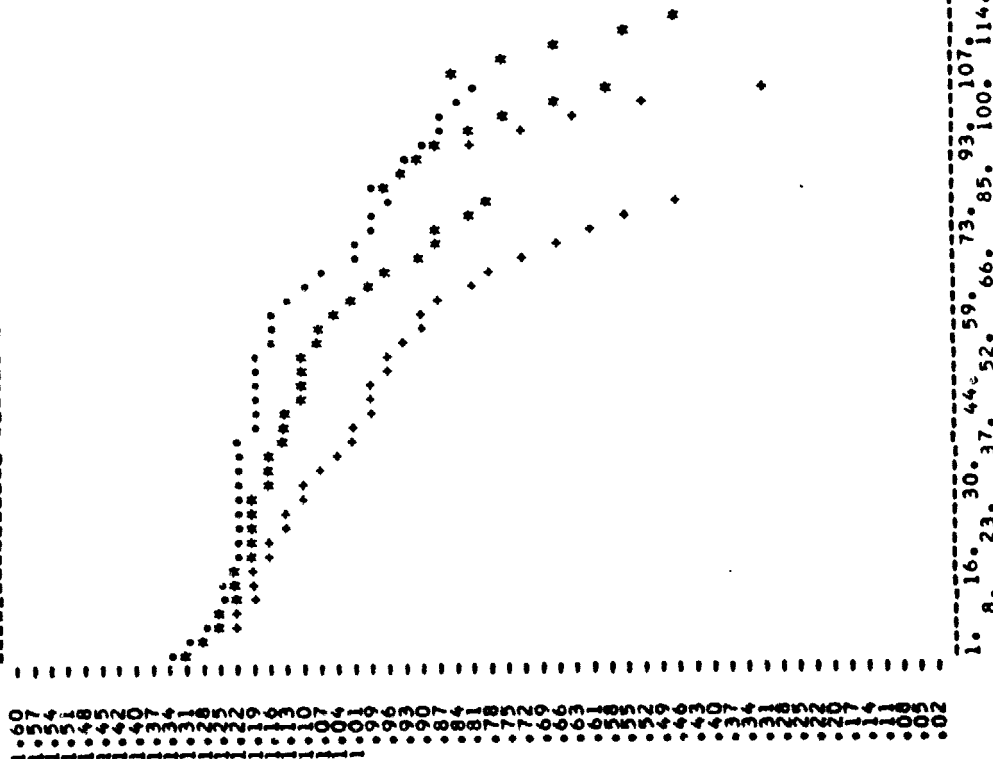
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PACK NUMBER IS 206A
SHADOW PERIOD IS 22
CYCLE NUMBER IS 4085
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

1.5 1.06 2.00 2.93 3.85 4.78 5.72 6.58
.62 1.54 2.47 3.39 4.32 5.24 6.18 7.05

KEY
* HIGH CELL
* LOW CELL
* AVERAGE



TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3

FIGURE 90

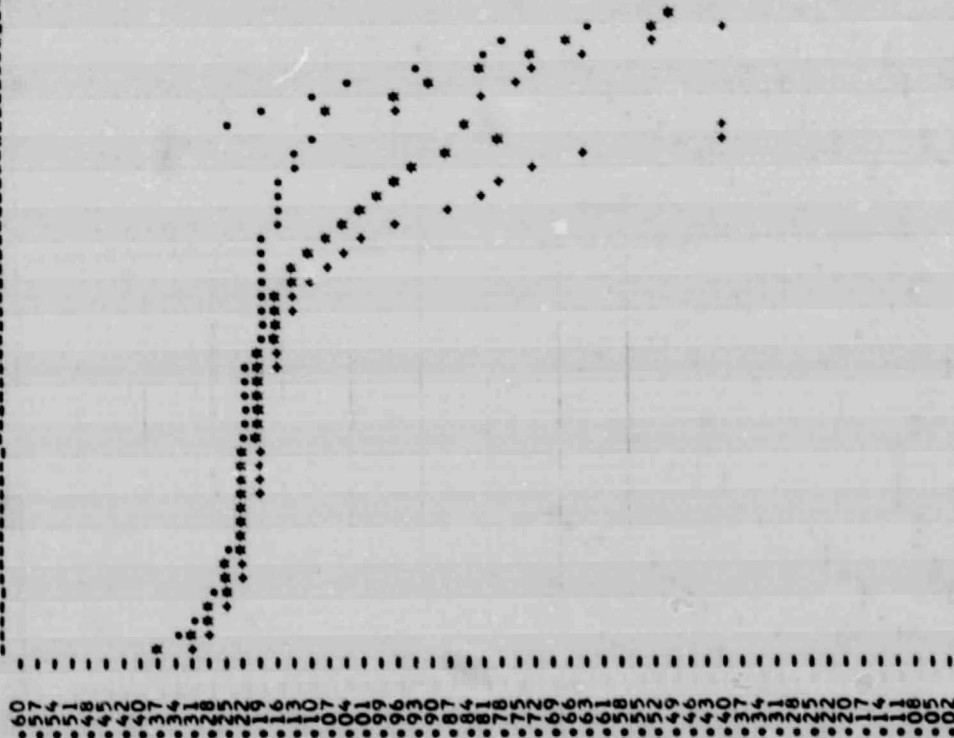
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PACK NUMBER IS 206A
POST CYCLING
CYCLE NUMBER IS 4086
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

.07 1.00 1.93 2.86 3.80 4.73 5.67 6.45
.54 1.47 2.40 3.33 4.27 5.20 5.99 6.88



1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 104. 114.
TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3

FIGURE 91

DEPTH DISCHARGE 80 WQEC/C 81-120A
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 6-6,6-9,11-15,11-37,11-39
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 206A

KEY
 * HIGH END DISCHARGE VOLTAGE
 * AVE END DISCHARGE VOLTAGE
 * LOW END DISCHARGE VOLTAGE

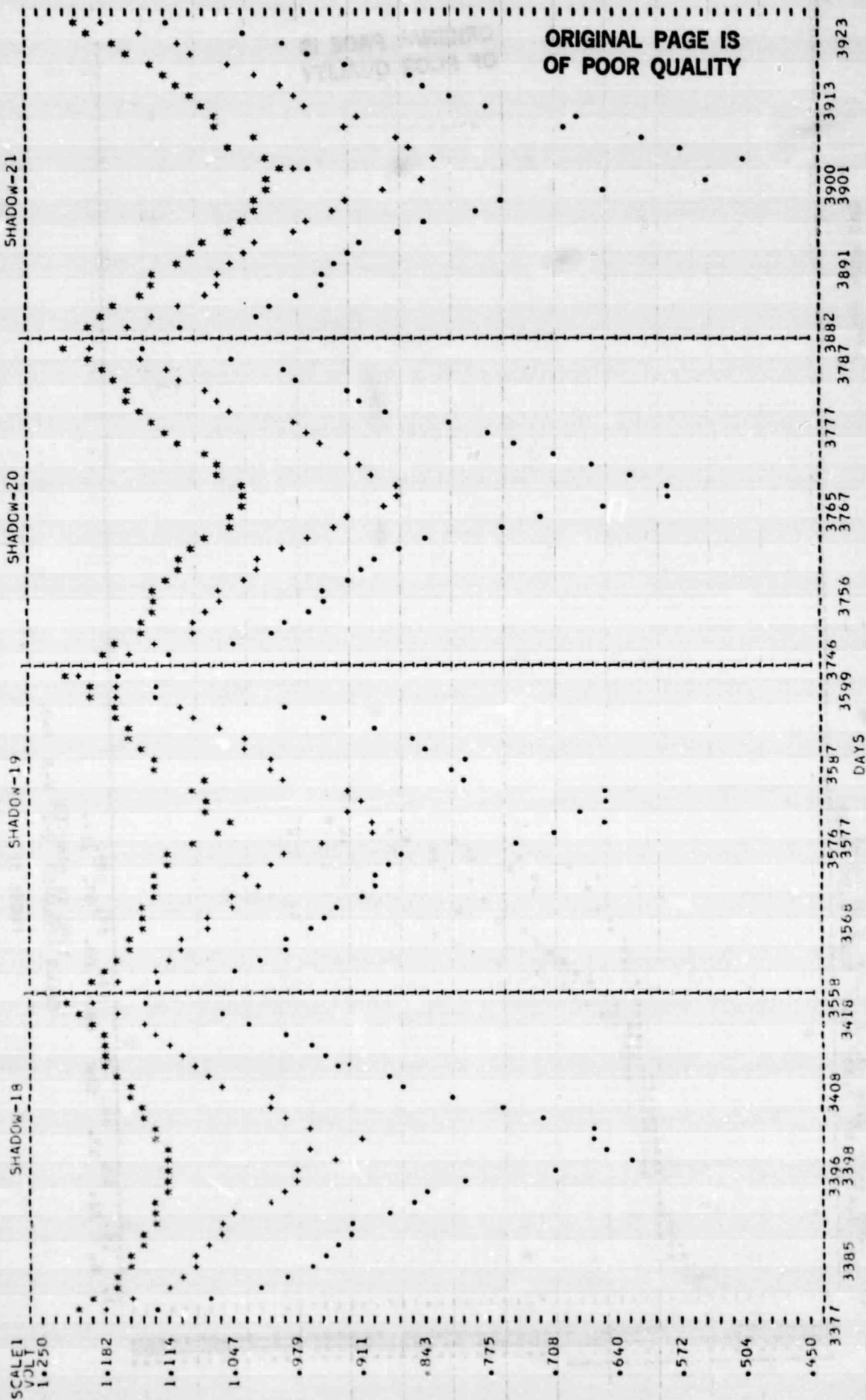


FIGURE 92

END DISCHARGE VOLTAGE
END DISCHARGE VOLTAGE
END DISCHARGE VOLTAGE

PACK = 206A

DEPTH DISCHARGE 80
TEMPERATURE 00
EMPTY RATE 06
SERIAL 6-6-6-11-15-11-37-11-39
GENERAL ELECTRIC CELLS

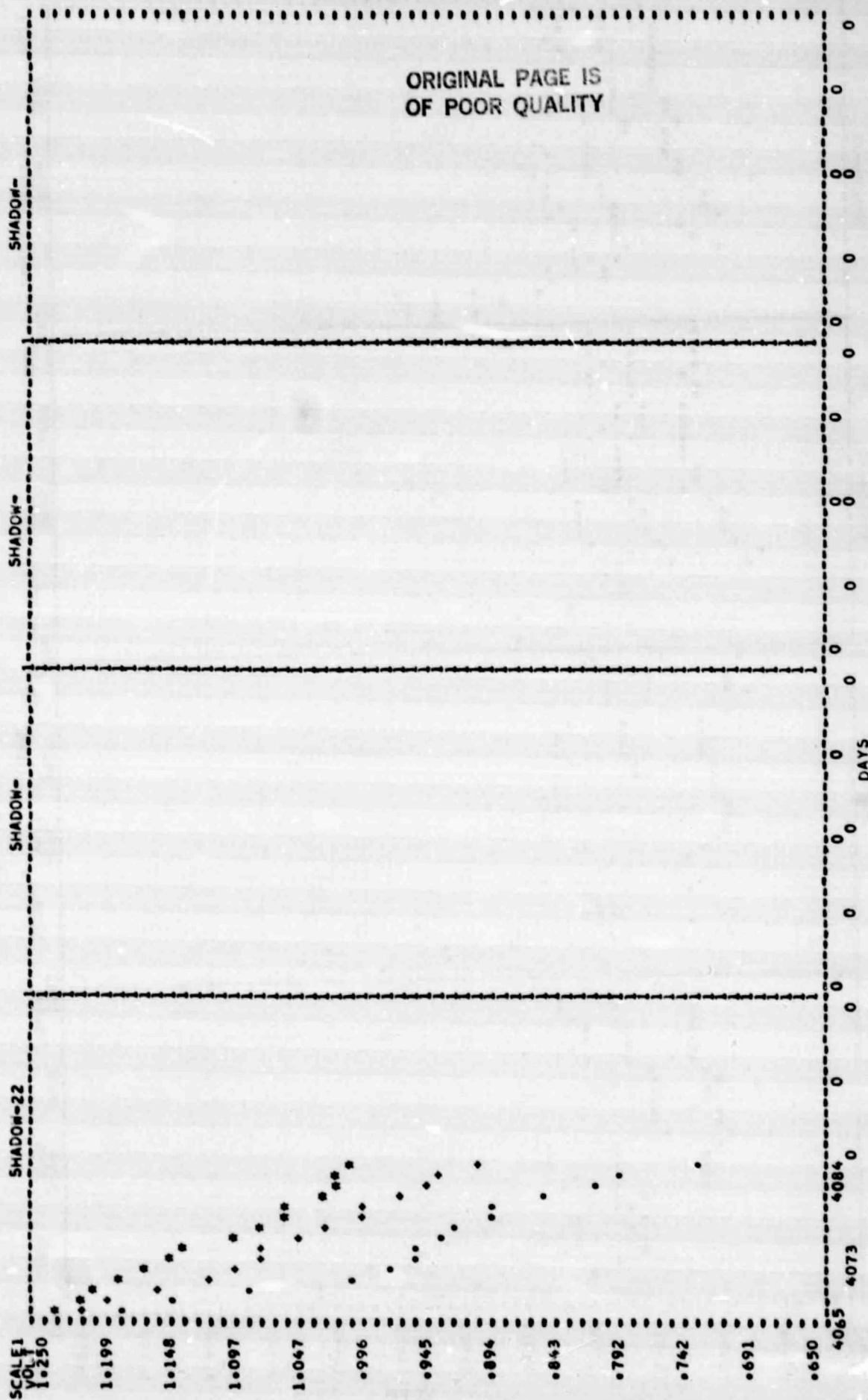
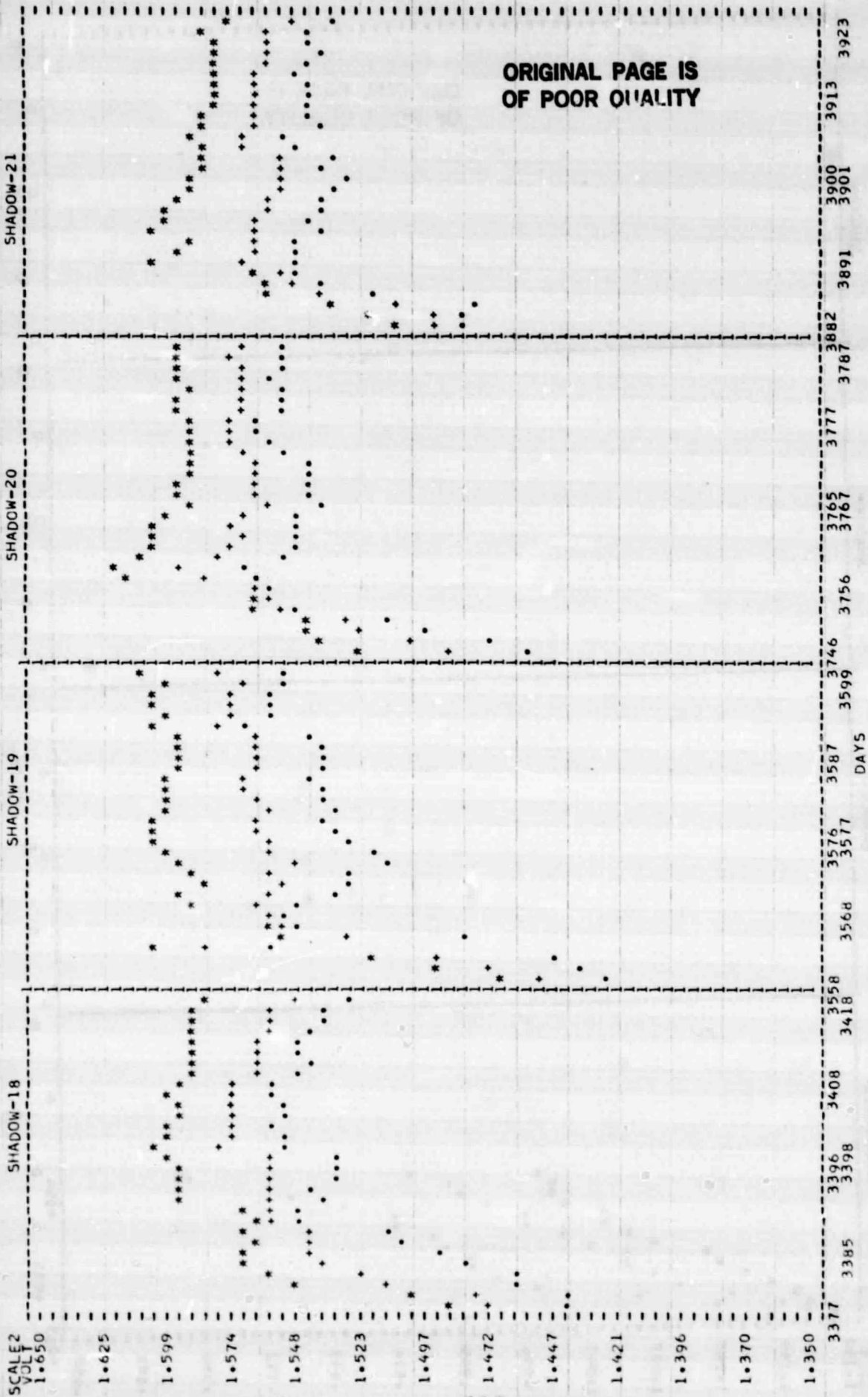


FIGURE 93

DEPTH DISCHARGE 80
 TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 6-6, 6-9, 11-15, 11-37, 11-39
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 206A



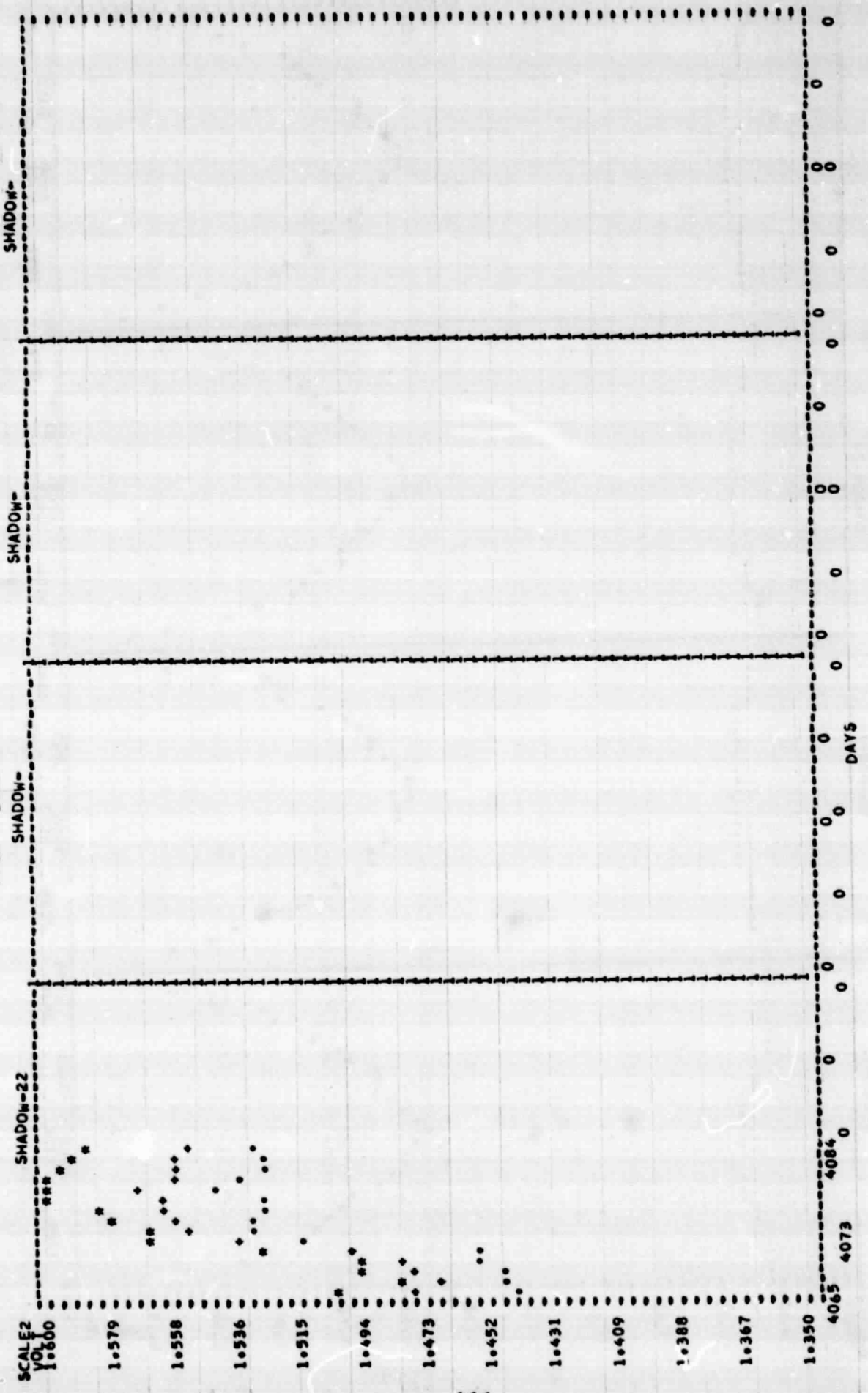
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FIGURE 94

DEPTH DISCHARGE 80 MQEC/C 81-120A
 TEMPERATURE 00
 HUMIDITY 00
 AIR PRESSURE 00
 WIND SPEED 00
 WIND DIRECTION 00
 GENERAL 00
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT
 PACK = 206A

KEY
 * HIGH EDC
 • AVE EDC
 • LOW EDC



TEMPERATURE 00
 AMPERE RATE 06
 SERIAL 6-6-9.11-15.11-37.11-39
 GENERAL ELECTRIC CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 206A

SHADOW-21

SHADOW-20

SHADOW-19

SHADOW-18

SCALE
 AHI-AHI
 10.50

9.65

8.81

7.96

7.11

6.26

5.42

4.57

3.72

2.87

2.03

1.18

.00

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3377 3385 3396 3408 3418 3558 3568 3576 3587 3599 3746 3756 3765 3777 3787 3882 3891 3900 3901 3913 3923

DAYS

FIGURE 96

KEY
• ANI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

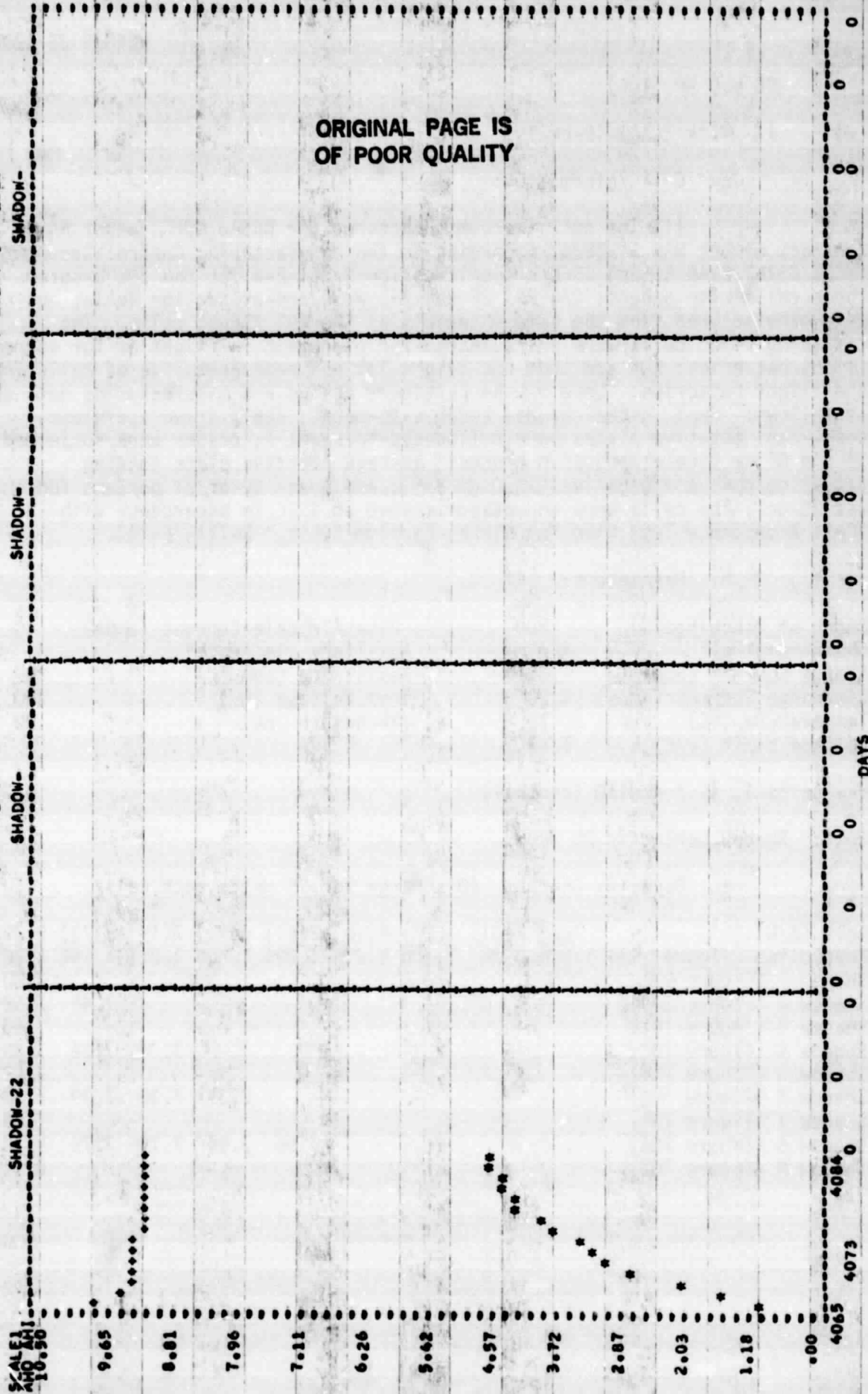
DEPTH DISCHARGE 80 MQEC/C 81-120A
TEMPERATURE 00
TEMPERATURE RATE 06
SERIAL 6-8-81-11-37,11-39
GENERAL ELECTRIC CELL 5

SHADOW-22

SHADOW-

SHADOW-

SHADOW-



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FIGURE 97

C. GE 6.0 ah (IUE)

1. Pack 231A, 10-cells

a. Cell information:

(1) The cells were manufactured for NASA, GSFC, under NASA contract number NAS 5-22838, according to the Manufacturing Control Document (MCD) 232A2222AA-81 and GSFC's specification S-761-P-6 for the IUE program. Three cells with gauges; S/N 27, 28 and 29. were pre-production cells; but were manufactured from the same materials as the IUE flight cells. The remaining seven cells were not selected for placement in flight or for spare flight batteries; but are from the flight lot and representative of cells in the flight batteries. Some of the pertinent design and manufacturing data are as follows: dual, nickel-braze, ceramic-to-metal, seal; drawn stainless steel can; negative plates were teflonated to Level I; plates were subjected to the GE carbonate reduction process; average positive plate loading (12.72 gm/dm^2) and negative (16.2 gm/dm^2); and quantity of 31 percent KOH was 25 cc. The cells were acceptance tested at GSFC in accordance with "Cell Acceptance Test Plan for Nickel-Cadmium Cells," X-711-76-143.

b. Parameters:

| | | | |
|--------------------------|-------|------------------------------|-----|
| Depth of Discharge(%) | 80 | Float/Trickle Current (amps) | .10 |
| Charge Control | AE/VL | Auxiliary Electrode*: | |
| Charge Current (amps) | .60 | Resistance (ohms) | 300 |
| Discharge Current (amps) | 4.00 | Trip Voltage (mv) | 150 |
| Temperature (°C) | 10 | Bandwidth (mv) | 90 |
| Voltage Limit (v/c) | 1.47 | | |

*-- cells 1, 4, 7 and 10 (control)

Note: Shadow period is 25 days.

c. Capacity Checks: (Discharge to .75 volts each cell)

| Cell (S/N) | 1(8) | 2(31) | 3(27) | 4(16) | 5(61) | 6(28) | 7(19) | 8(73) | 9(29) | 10(20) |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Precycling (Figure 98) | 1.206 | 6.34 | 1.206 | 1.205 | 1.205 | 1.206 | 1.211 | 1.192 | 1.205 | 1.199 |
| Shadow 1 (Figure 99) | | | | | | | | | 7.20 | 1.151 |
| Shadow 2 (Figure 100) | | | | | | | | 7.48 | 7.58 | 7.48 |
| Shadow 3 (Figure 101) | | | | | | | | | 7.63 | 7.28 |
| Shadow 4 (Figure 102) | | | | | | | 7.34 | 7.34 | 7.49 | 7.14 |
| Shadow 5 (Figure 103) | | | | | | | | | 7.59 | 7.20 |
| Shadow 6 (Figure 104) | | | | | | 7.39 | 7.39 | 7.39 | 7.58 | 7.19 |
| Shadow 7 (Figure 105) | | | | | | | | | 7.85 | 7.46 |
| Shadow 8 (Figure 106) | | | | | 7.56 | 7.56 | 7.76 | 7.76 | 8.10 | 7.56 |
| Shadow 9 (Figure 107) | | | | | | | | | 8.11 | 7.56 |

d. Test results during the Shadow Periods: (Figures 108 to 113)

(1) End of Discharge Voltages: The average voltages, the day prior to the capacity check, have decreased from 1.234 (shadow 1) to 1.153 volts (shadow 9). The averages of cells 9 and 10, which are always capacity checked, were 1.163 volts (shadow 9); while the average of cells 1 through 4, which have not been capacity checked, were 1.142 volts. Cell 9 has always exhibited the highest voltage with cell 4 having the lowest. The decrease in voltages, following the capacity checks, is due to those cells being on open-circuit for 24 hours during these checks. Low cell voltages, during the first part of shadow 1, were due to insufficient recharge caused by the control unit.

(2) Capacity/Reconditioning Effects: There has been no capacity degradation since shadow 4. Beginning with shadow 5, the capacity has increased due to an increase in the ampere-hour input during charge. This increase is discussed in part (4). There has been a degradation in voltage, beginning with shadow 4's capacity check in which the percent of the total capacity available between 1.10 and 1.00 volts has increased as follows:

| Shadow 4 | | Shadow 6 | | Shadow 8 | | Shadow 9 | |
|----------|--------|----------|--------|----------|--------|----------|--|
| Cell 7** | Cell 9 | Cell 6** | Cell 9 | Cell 5** | Cell 9 | Cell 9 | |
| 16% | 15% | 27% | 22% | 29% | 24% | 25% | |

**-- initial capacity check.

The capacity available below 1.000 volts ranged from 4 to 7 percent. The reconditioning effect, due to the capacity checks, is more pronounced in the middle of the shadows than at the beginning or end when comparing EOD voltages. There is a reconditioning effect due to the daily discharge of the pack as is obvious from the graphs which show higher values for the low end discharge voltages during the last half of each shadow. The average discharge voltages of those cells which were capacity checked increased the day following their capacity check: cells 7 and 8 (25 mv, shadows 2 and 4), cells 5 and 6 (34 mv, shadows 6 and 8), cells 9 and 10 (15 mv, shadow 9).

(3) Voltages at Trip and End of Charge: There has been an increase in these voltages since shadow 1. The increase is due to the apparent loss of sensitivity of the controlling auxiliary electrode (cell 10). During shadow 9, the voltages of this electrode were 90 to 120 mv less than the other electrodes in the pack at the end-of-charge with the cell voltages being the same. Also, during discharge, this electrode's voltage would increase 130 mv at the start of discharge and be above its EOC value at the end-of-discharge. The control was changed to cell 4's electrode towards the end of shadow 9, on days 1341 and 1342, which resulted in lower trip and end of charge voltages. Investigation showed that the control unit is not responsible for the erratic behavior of cell 10's electrode. The first 6 days of shadow 9, the pack reached its voltage limit of 1.47 v/c before cell 10's electrode voltage reached its trip of 150 mv. This was also the case during portions of shadows 7 and 8. The trip voltages plotted are those when the current began to decrease, whether it was due to the auxiliary electrode trip or when the pack reached its voltage limit.

(4) Ampere-Hour Input: The mid-shadow input at end-of-charge has increased from a low of 5.68 (shadow 1) to 10.03 ampere-hours (shadow 9). This is due to the loss of the controlling electrode's sensitivity and accounts for the increase in capacity obtained during the capacity checks. The increase in the input during the second half of shadow 2 is due to hardware problems in which the current was not reduced below .50 amperes for all but the last 3 days of the shadow. The decrease in input during days 1341 and 1342 of shadow 9 is due to the auxiliary electrode control being on cell 4.

(5) Pressures at End of Charge: The pressures have increased as the ampere-hour input has increased. The average pressures, the day prior to the capacity checks, was 11 psia for shadow 1, 30 psia for shadow 6, and 51 psia for shadow 9. Cell 9 has always exhibited the highest pressure and for shadow 9 it was 62 psia.

e. Performance during Sun Periods: The pack has completed eight sun periods as it began test with a shadow period. Pressures, at the end of each period have not exceeded 25 psia. Following is a listing of the high, average and low cell voltages at the start and end of each sun period.

SUN PERIODS

| Voltages*** | 1 | | | 2 | | | 3 | | |
|-------------|-------------------|----------------|--|-------------|---------------|--|--------------|----------------|--|
| | Start | End | | Start | End | | Start | End | |
| High | 1.431 (1,2) | 1.435 (6) | | 1.423 (4) | 1.429 (6) | | 1.433 (5,7) | 1.430 (1,4,10) | |
| Average | 1.430 | 1.432 | | 1.415 | 1.426 | | 1.431 | 1.429 | |
| Low | 1.428 (3,5) | 1.430 (9) | | 1.408 (9) | 1.423 (9) | | 1.428 (9,10) | 1.427 (3,9) | |
| Voltages | 4 | | | 5 | | | 6 | | |
| | Start | End | | Start | End | | Start | End | |
| High | 1.432 (1,2,5,6,7) | 1.435 (2,7,10) | | 1.431 (1,4) | 1.432 (6) | | 1.430 (1) | 1.431 (1,5) | |
| Average | 1.431 | 1.432 | | 1.425 | 1.431 | | 1.429 | 1.430 | |
| Low | 1.429 (3) | 1.428 (8) | | 1.418 (9) | 1.430 (1,4,5) | | 1.428 (9) | 1.428 (8,10) | |
| Voltages | 7 | | | 8 | | | | | |
| | Start | End | | Start | End | | | | |
| High | 1.438 (4) | 1.442 (8) | | 1.438 (7) | 1.441 (7) | | | | |
| Average | 1.431 | 1.439 | | 1.435 | 1.440 | | | | |
| Low | 1.424 (9) | 1.436 (10) | | 1.433 (2,9) | 1.438 (9) | | | | |

***--() indicates which cell

CELL NUMBER IS 2312
 DEF-CYCLING
 CYCLE NUMBER IS 4
 DISCHARGE RATE IS 4A

AMPERE HOUR OUT

1. 1.06 2.02 2.09 3.94 4.90 5.86
 1.54 2.50 3.46 4.42 5.38 6.34

CELL VOLTAGE SCALE
 HIGH CELL
 LOW CELL
 AVERAGE

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1. 8. 16. 23. 30. 38. 45. 52. 59. 66. 73. 80. 88. 95.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5 V-6 V-7 V-8 V-9 V-10

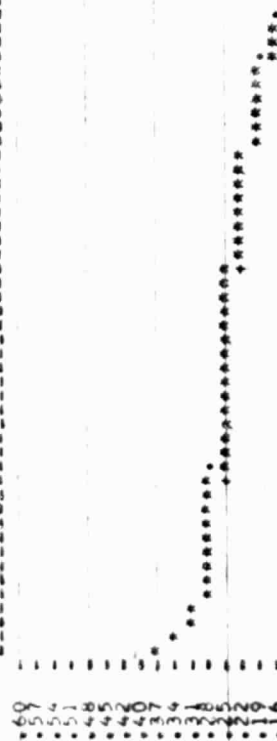
FIGURE 98

PACK NUMBER IS 231A
SHADOW PERIOD IS 01
CYCLE NUMBER IS 17
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

KEY HIGH CELL
• LOW CELL
• AVERAGE

00. 44. 93. 1.89 2.38 3.83 4.79 5.27 6.72 7.20



ORIGINAL PAGE IS
OF POOR QUALITY

1. 8. 16. 23. 30. 37. 45. 52. 59. 66. 73. 80. 88. 95. 102. 109.

TIME IN MINUTES
CELLS INCLUDED V-9 V10

FIGURE 99

ORIGINAL PAGE IS
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AMPERE HOUR OUT

PACK NUMBER IS 5312
SHADOW PERIOD IS 2
CYCLE NUMBER IS 108
DISCHARGE RATE IS 4.0

0.00 0.97 1.95 2.92 3.90 4.88 5.85 6.83 7.58
0.00 1.46 2.44 3.41 4.39 5.37 6.34 7.32

KEY HIGH CELL
• LOW CELL
• AVERAGE

C
A
P
A
C
I
T
Y
C
E
L
L
V
O
L
T
A
G
E
S
C
A
L
E

1.00
1.02
1.04
1.06
1.08
1.10
1.12
1.14
1.16
1.18
1.20
1.22
1.24
1.26
1.28
1.30
1.32
1.34
1.36
1.38
1.40
1.42
1.44
1.46
1.48
1.50
1.52
1.54
1.56
1.58
1.60
1.62
1.64
1.66
1.68
1.70
1.72
1.74
1.76
1.78
1.80
1.82
1.84
1.86
1.88
1.90
1.92
1.94
1.96
1.98
2.00

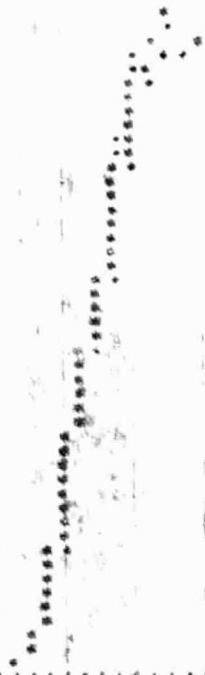
1. 8. 15. 23. 30. 37. 44. 51. 59. 66. 73. 81. 87. 95. 102. 109. 113.
TIME IN MINUTES
CELLS INCLUDED V-8 V-9 V10

FIGURE 100

AMPERE HOUR CAP

PAGE NUMBER IS 2314
SHIPPING PERIOD IS 03
CYCLE NUMBER IS 0232
DISCHARGE RATE IS 4.

1. 1.05 1.51 2.02 2.46 2.92 3.44 3.91 4.37 4.84 5.33 5.81 6.33 6.81 7.28



ORIGINAL PAGE IS
OF POOR QUALITY

1. 18. 20. 23. 27. 31. 37. 44. 51. 58. 66. 73. 81. 87. 94. 102. 109. 121.

CR-5 INCLUDES 1-9 VIO

FIGURE 101

PACK NUMBER IS 231A
SHADOW PERIOD IS 4.415
CYCLE NUMBER IS 4.415
DISCHARGE RATE IS 4.

AMPERE HOUR UNIT

KEY
+ HIGH CELL
+ LOW CELL
+ AVERAGE

07 1.02 1.99 2.95 3.92 4.88 5.85 6.82 7.49
54 1.50 2.47 3.43 4.40 5.37 6.33 7.18

607
574
551
548
522
420
374
333
318
239
229
211
110
07
001
009
003
007
87
81
72
72
69
63
61
55
52
49
46
40
37
33
28
22
20
14
11
08
02

C A P A C I T Y C E L L V O L T A G E S C A L E

ORIGINAL PAGE IS
OF POOR QUALITY

1. 8. 15. 22. 29. 37. 44. 51. 58. 65. 73. 80. 87. 94. 101. 113.

TIME IN MINUTES
CELLS INCLUDED V-7 V-8 V-9 V10

FIGURE 102

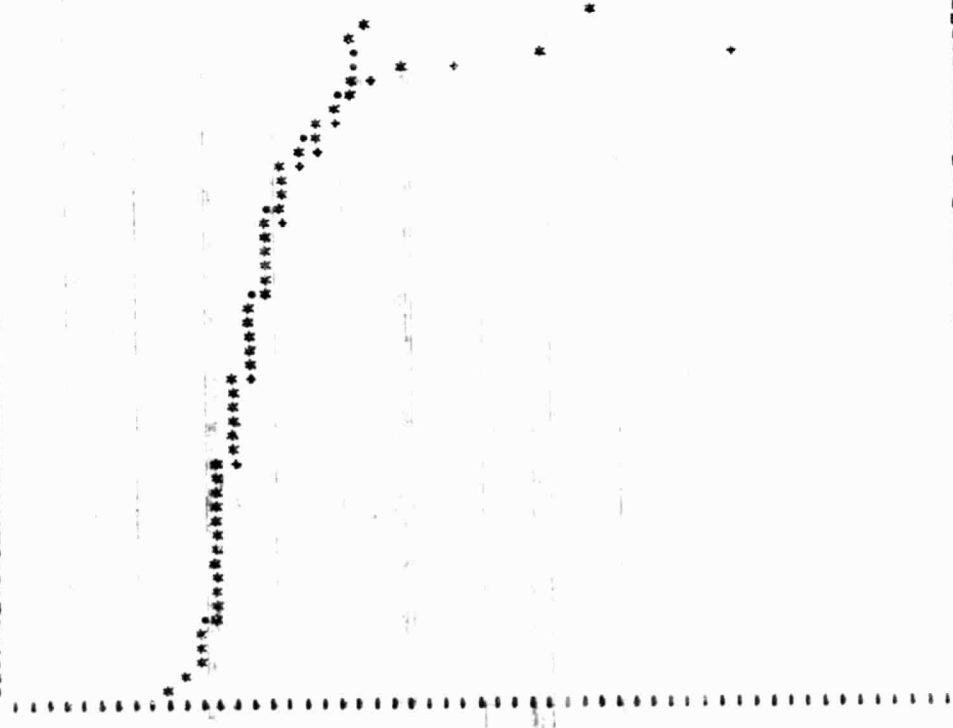
PACK NUMBER IS 231A
 SPADON PERIOD IS 05
 CYCLE NUMBER IS 95
 DISCHARGE RATE IS 4.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

1.2 1.08 2.02 2.98 3.89 4.83 5.76 6.72 7.59
 .60 1.56 2.50 3.44 4.35 5.31 6.24 7.20

C A P A C I T Y C E L L V O L T A G E S C A L E



ORIGINAL PAGE IS
 OF POOR QUALITY

1. 8. 16. 22. 29. 37. 44. 51. 58. 65. 73. 79. 85. 92. 99. 107. 128.

TIME IN MINUTES
 CELLS INCLUDED V-9 V10

FIGURE 103

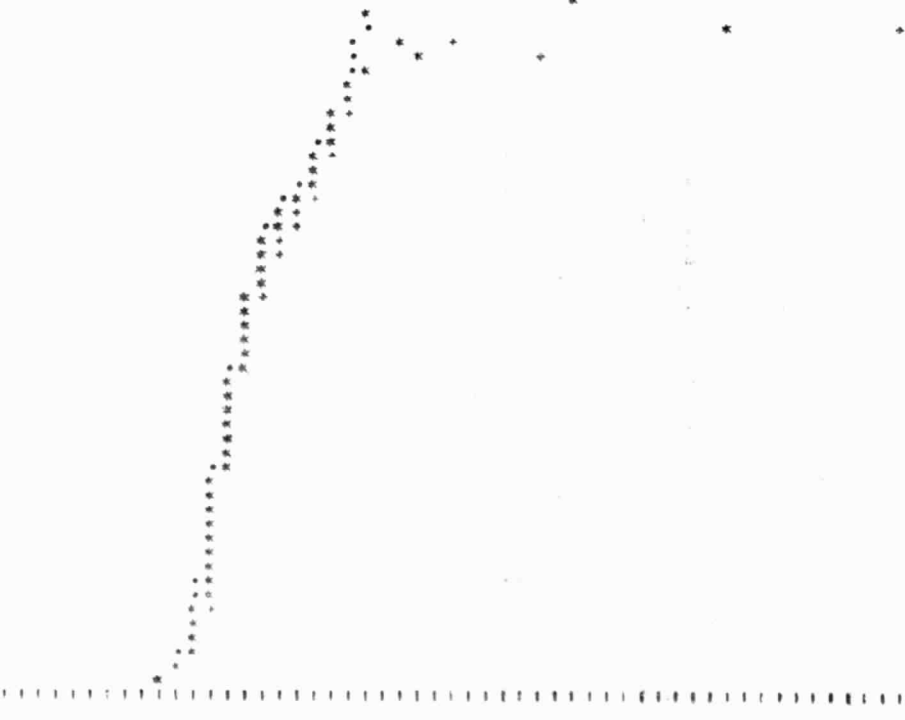
CELL
AVERAGE

BACK 5.00
SADON PERIOD 15.00
CYCLE NUMBER 15
DISCHARGE RATE 15

AMPERE HOUR OUT

11 1.07 2.04 3.00 3.97 4.93 5.90 6.87 7.56
59 1.55 2.52 3.49 4.45 5.41 6.38 7.23

1.00
1.01
1.02
1.03
1.04
1.05
1.06
1.07
1.08
1.09
1.10
1.11
1.12
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1.81
1.82
1.83
1.84
1.85
1.86
1.87
1.88
1.89
1.90
1.91
1.92
1.93
1.94
1.95
1.96
1.97
1.98
1.99
2.00



1. 9. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 116.

TIME IN MINUTES
CELLS INCLUDED V-6 V-7 V-8 V-9 V10

FIGURE 104

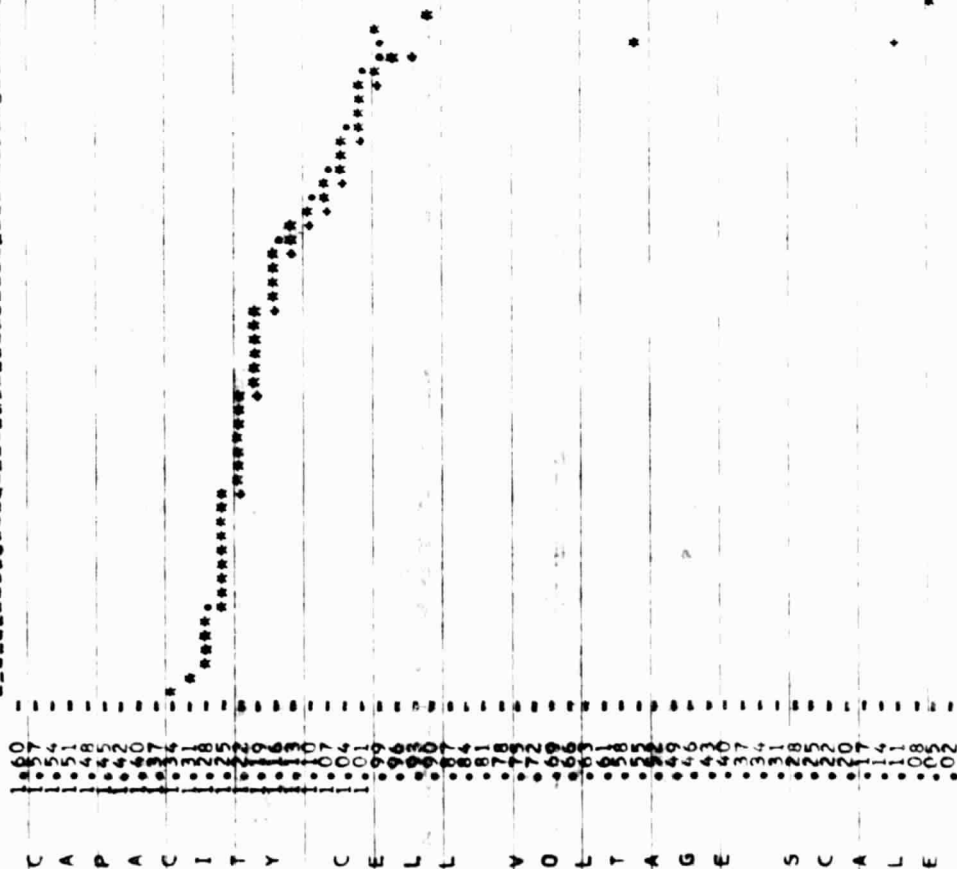
ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 231A
SHADOW PERIOD IS 07
CYCLE NUMBER IS 967
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

1.15 1.10 2.06 3.01 3.97 4.92 5.87 6.83 7.69 7.85
.63 1.58 2.53 3.49 4.44 5.40 6.35 7.30



ORIGINAL PAGE IS
OF POOR QUALITY

1. 8. 15. 30. 44. 58. 67. 73. 87. 94. 102. 109. 116. 118.

TIME IN MINUTES
CELLS INCLUDED V-9 V10

FIGURE 105

PACK NUMBER IS 231A
SHADOW PERIOD IS 0A
CYCLE NUMBER IS 1153
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

11. 1.06 2.01 2.96 3.92 4.87 5.82 6.77 7.76
59. 1.54 2.49 3.44 4.39 5.34 6.29 7.24 8.10

C 1.40
A 1.57
P 1.51
A 1.48
A 1.45
A 1.42
C 1.37
C 1.34
I 1.31
I 1.28
Y 1.25
Y 1.22
Y 1.19
Y 1.16
Y 1.13
Y 1.10
Y 1.07
Y 1.04
Y 1.01
Y 0.98
Y 0.95
Y 0.92
Y 0.89
Y 0.86
Y 0.83
Y 0.80
Y 0.77
Y 0.74
Y 0.71
Y 0.68
Y 0.65
Y 0.62
Y 0.59
Y 0.56
Y 0.53
Y 0.50
Y 0.47
Y 0.44
Y 0.41
Y 0.38
Y 0.35
Y 0.32
Y 0.29
Y 0.26
Y 0.23
Y 0.20
Y 0.17
Y 0.14
Y 0.11
Y 0.08
Y 0.05
Y 0.02

ORIGINAL PAGE IS
OF POOR QUALITY

1. 8. 15. 22. 30. 37. 44. 52. 58. 66. 73. 80. 87. 94. 102. 109. 116. 126.

CELLS INCLUDED V-5 V-6 V-7 V-8 V-9 V10

FIGURE 106

PACK NUMBER IS 231A
SHADOW PERIOD IS 09
CYCLE NUMBER IS 1332
DISCHARGE RATE IS 4.

AMPERE HOUR OUT

1.2 1.00 1.96 2.92 3.58 4.84 5.80 6.76 7.63
.52 1.48 2.44 3.40 4.36 5.32 6.28 7.24 8.11

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

C 1.67
A 1.54
P 1.51
A 1.48
C 1.45
I 1.42
T 1.39
V 1.36
C 1.33
E 1.30
L 1.27
L 1.24
V 1.21
O 1.18
L 1.15
T 1.12
A 1.09
S 1.06
C 1.03
A 1.00
L 0.97
E 0.94

ORIGINAL PAGE IS
OF POOR QUALITY

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102. 109. 116. 124.

TIME IN MINUTES
CELLS INCLUDED V-9 V10

FIGURE 107

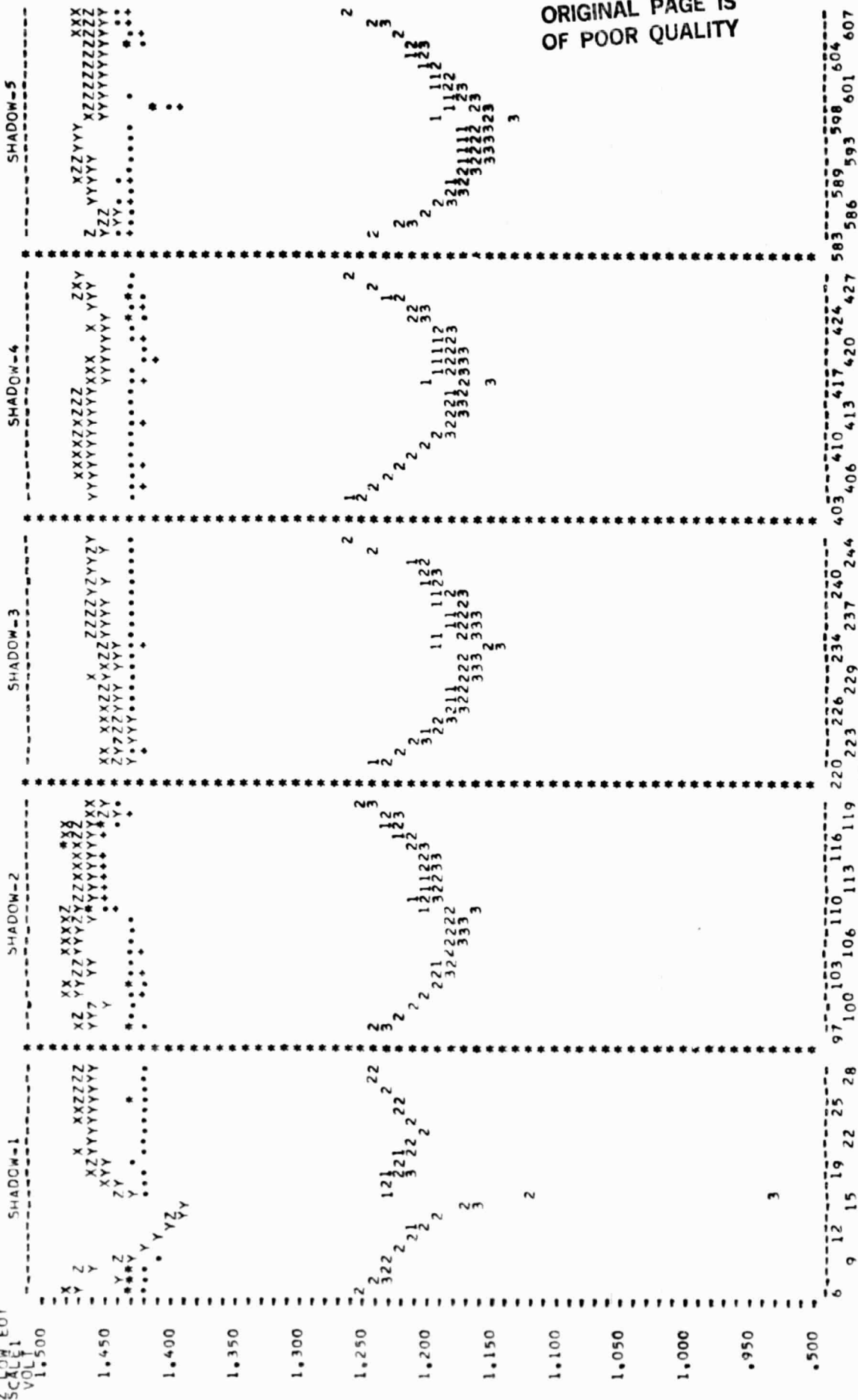
KEY
1 HIGH END DISCHARGE VOLTAGE
2 AVE END DISCHARGE VOLTAGE
3 LOW END DISCHARGE VOLTAGE
* HIGH EOC
* LOW EOC
* AVE EOC
* HIGH EOT
* AVE EOT
* LOW EOT
SCALING
VOLT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 80 WQEC/C 81-120A
TEMPERATURE 10
AMPERE RATE 06
GENERAL ELECTRIC CELLS

PROJECT IUE 031.027.016.061.
SERIAL 008.031.027.016.061.
08.019.073.029.020.

PACK = 231A



ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 108

WQEC/C 81-120A

DEPTH DISCHARGE 80
TEMPERATURE 10
AMPERE RATE 06
GENERAL ELECTRIC CELLS

PROJECT IUE
SERIAL 008 031 027 016 061,
028, 019, 073, 029, 020,

SHADOW-

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 231A

SHADOW-8

SHADOW-9

SHADOW-

KEY
1 HIGH END DISCHARGE VOLTAGE
2 AVE END DISCHARGE VOLTAGE
3 LOW END DISCHARGE VOLTAGE
• HIGH EOC
• AVE EOC
• LOW EOC
X HIGH EOT
Z LOW EOT
SCALE
VOLT

SHADOW-6

SHADOW-7

SHADOW-8

SHADOW-9

SHADOW-

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0 0 0 0 0 0 0

1344 1337 1334 1326 1323 1320 1316 1315 1165 1162 1159 1155 1147 1144 1141 979 976 973 969 964 961 958 955 798 795 792 788 783 780 777

DAYS

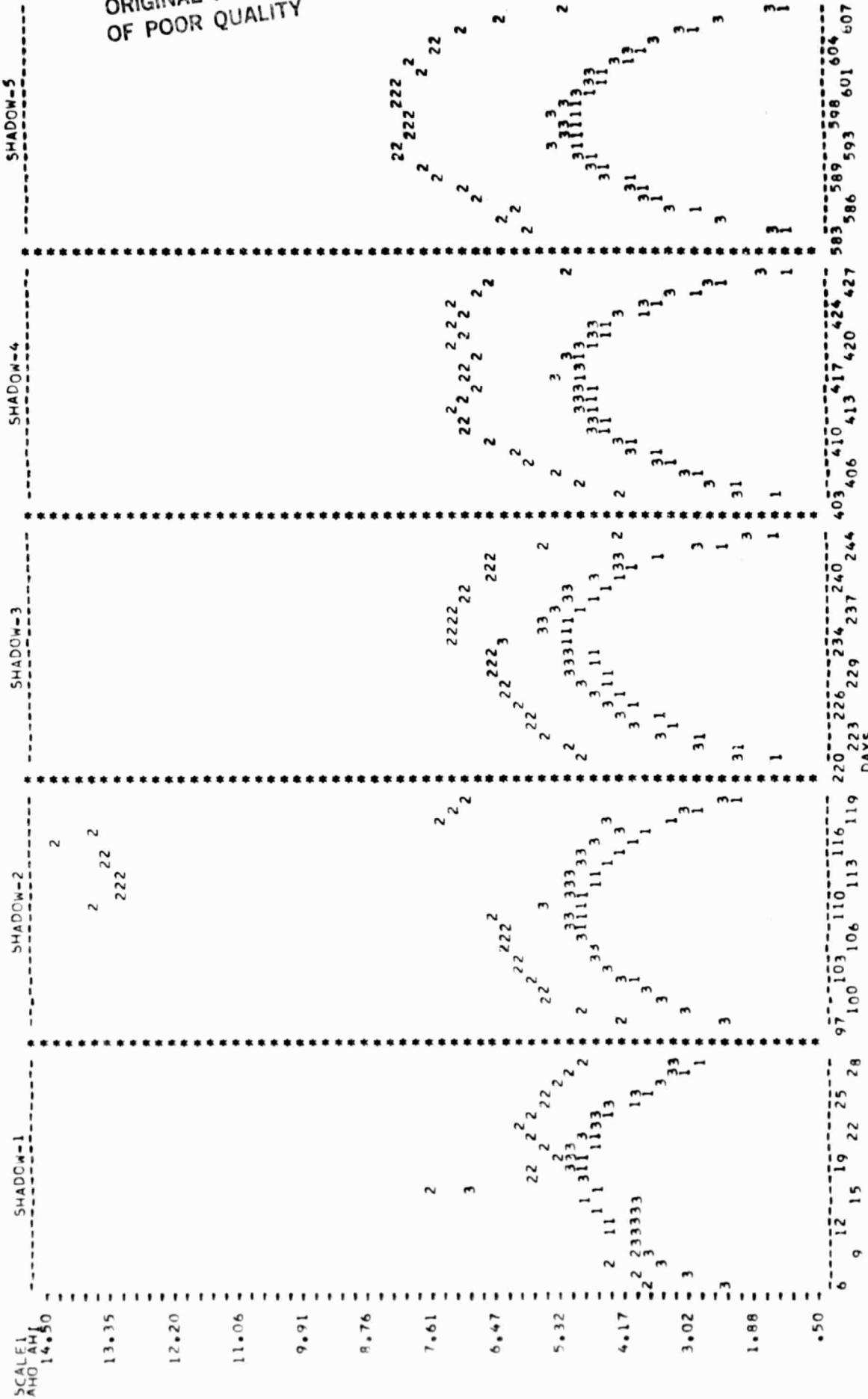
FIGURE 109

KEY
1 AHO
2 AHI
3 AHI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 80
TEMPERATURE 10
AMPERE RATE 06
SERIAL 008.031.027.016.061:
GENERAL 028.019.073.029.020:
PROJECT FUE
CELLS

PACK = 231A



ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 110

DEPTH DISCHARGE 10
TEMPERATURE 06
AMPERE RATE 0319.0
SERIAL 008, 019, 0
GENERAL ELECTRIC
PROJECT IUE

SYNCHRONOUS ORBIT SHADOW PLOT

PACH = 231A

KEY
1 AMO
2 AMI-TOTAL
3 AMIT-TOTAL

SCALE 1
ANO ANI
10.50

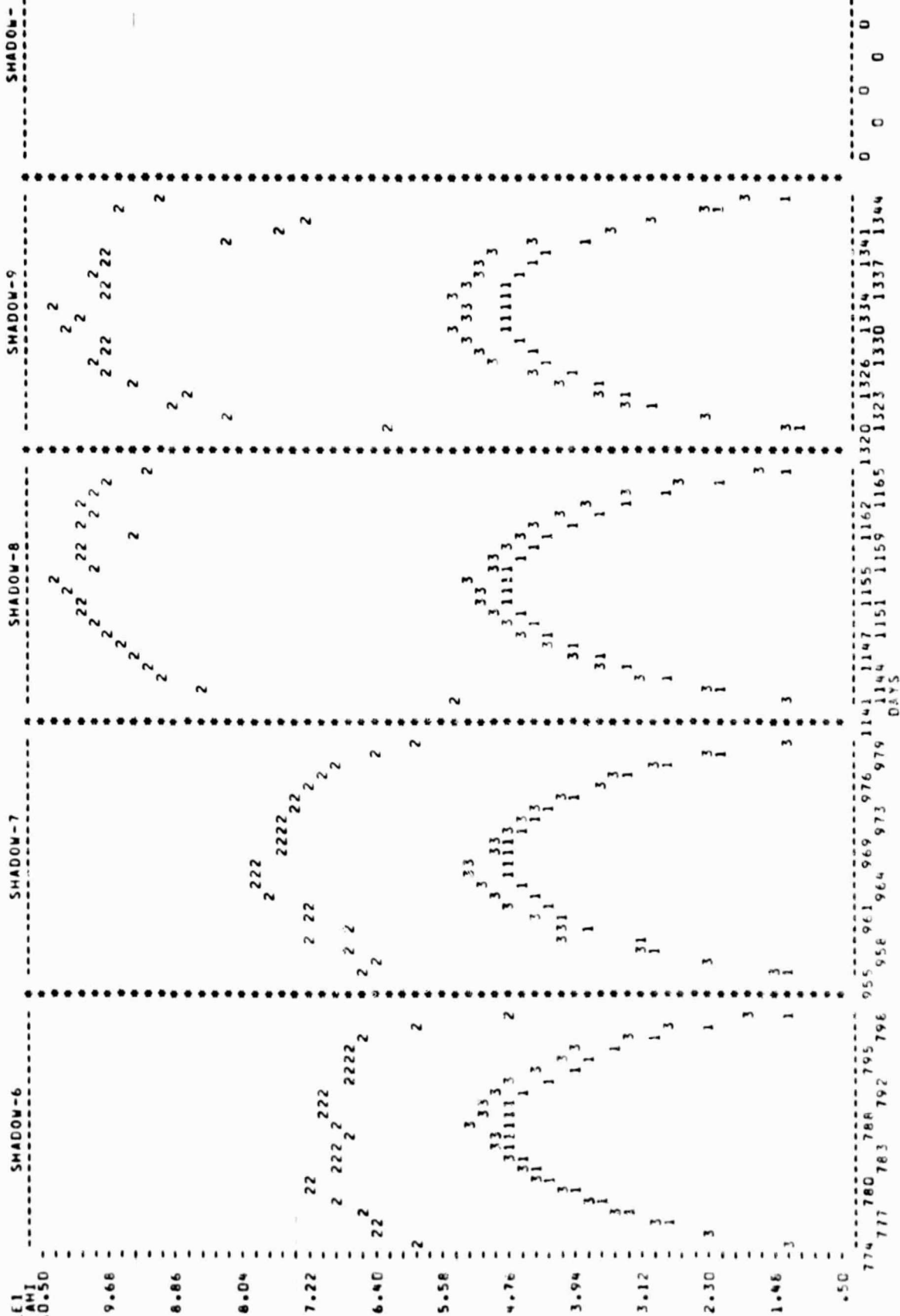


FIG. 17

KEY
• E46 CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPT 4 DISCHARGE 80 W0EC/C 81-120A
TEMPERATURE 10
AMPERE RATE 0.0027:016:061
SERIAL 008:031:027:016:061
028:019:073:029:020:

PROJECT IUE
GENERAL ELECTRIC CELLS

PACK = 231A

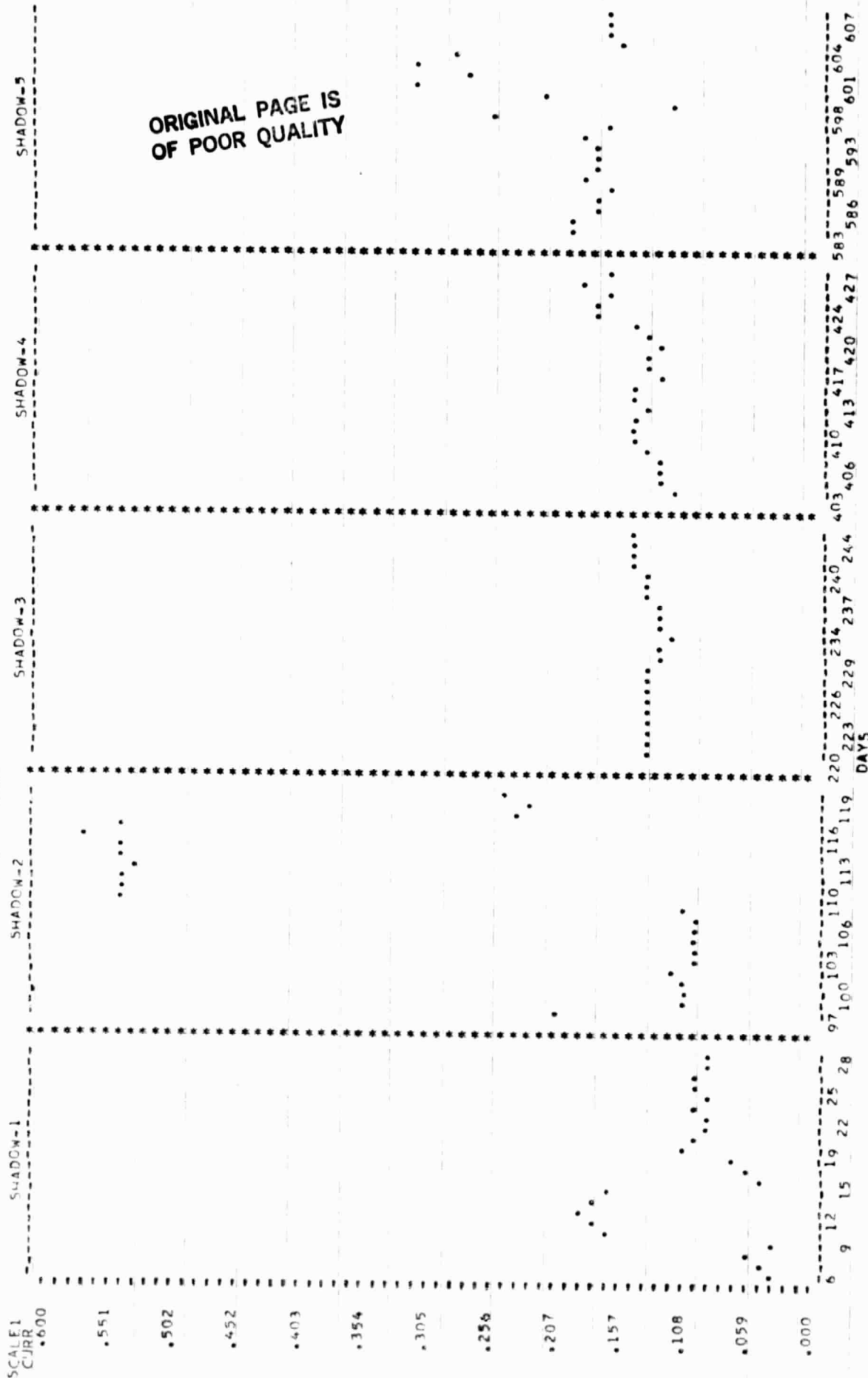


FIGURE 112

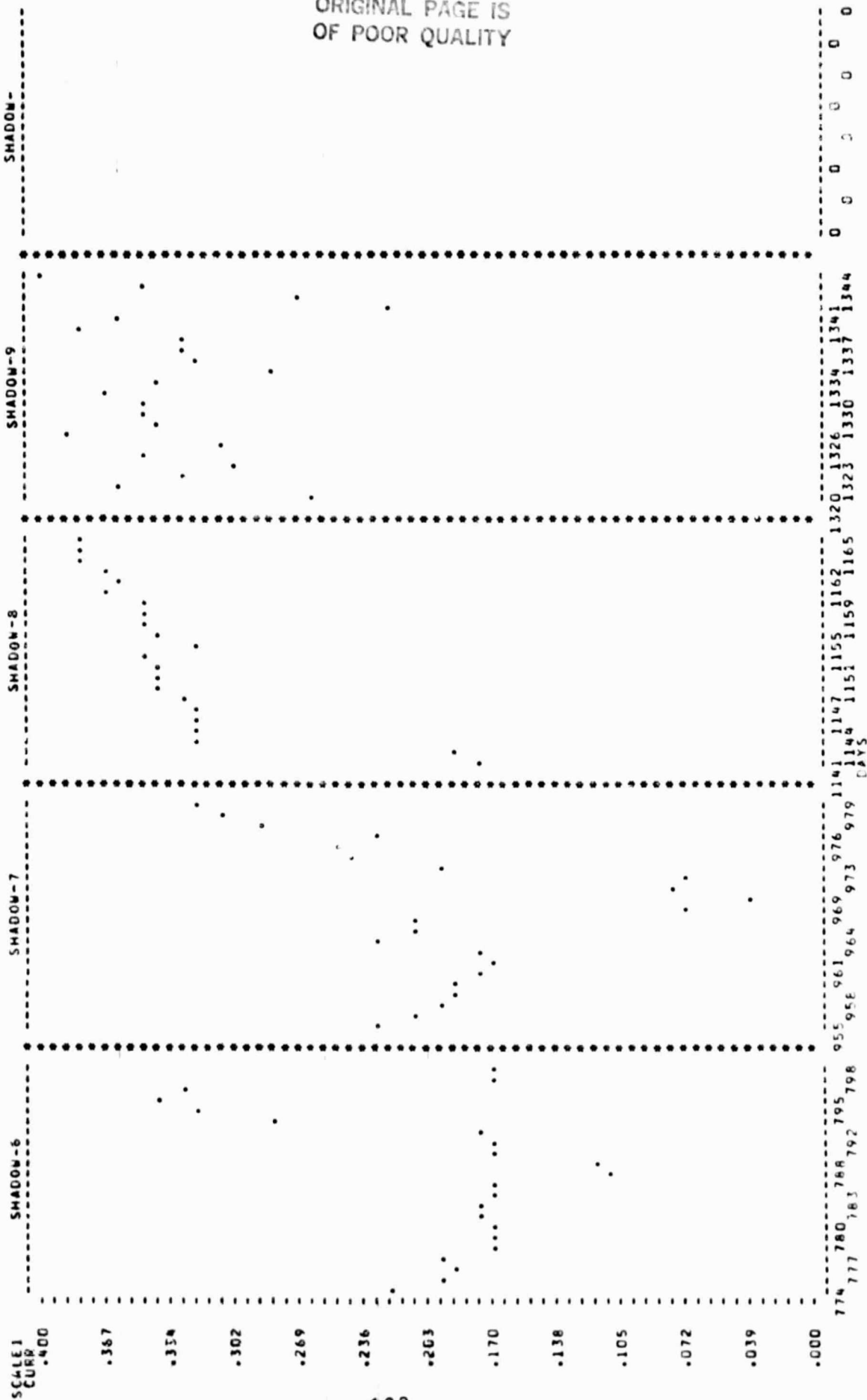
KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 MQEC/C 81-120A
TEMPERATURE 10
AMPERE RATE 06
SERIAL 008,031,027,016,061,
028,019,073,029,020,

PROJECT IUE
GENERAL ELECTRIC CELLS

PACK = 231A



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D. GE 6.0 ah (GOES D, E, and F)

1. Pack 227D, 7-cells, real-time test

a. Cell information: The cells were purchased by GSFC, under NASA Purchase Order Numbers S-53504-B and S-614478 from the General Electric Company. Two additional cells were supplied by Hughes Aircraft Company (HAC). All the cells were manufactured at the same time and from the same materials as the first lot of cells manufactured for HAC for the GOES-D, E, and F Satellite Program. These cells were manufactured in accordance with "Product Specification Hermetically Sealed Nickel-Cadmium Battery Cell-6AH-GOES," Hughes #PS 31999-013, Revision D. The two cells supplied by HAC were subjected to acceptance testing at HAC in accordance with "Acceptance Test Specification Sealed Nickel-Cadmium Battery Cell HS-371," TS 31999-021, prior to shipment to Crane. The cells were identified by the manufacturer's catalog number 42B006AB58-G1 and HAC's part number 259300. These cells are rated at 6.0 ampere-hours and contain single ceramic seals on the positive terminals. The last two cells in the pack are those supplied by HAC and cell 6 was fitted with a pressure transducer prior to testing. Initial evaluation test results, of those cells purchased by GSFC, are contained in NAVWPNSUPPCEN Crane Report WQEC/C 79-224.

b. Parameters:

| | | | |
|------------------------|-----|--------------------------|------|
| Depth of Discharge (%) | 52 | Discharge Current (amps) | 2.61 |
| Charge Control | CC | Temperature (°C) | 15 |
| Charge Current (amps)* | .26 | Float Current (amps) | .125 |

*-- Current was increased to .325 ips at the start of shadow 2. The current is decreased 5 ma for each succeeding shadow.

c. Capacity Check: ** (Discharge to .75 volts any cell prior to the start of each shadow period.)

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell
5 | Cell
6 | Cell
7 | ah |
|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------|
| Precycling (Figure 114) | 7.14 | 7.14 | 7.17 | 7.17 | 7.17 | 7.14 | 6.98 | |
| Shadow 2 (Figure 115) | 1.047 | 1.059 | 1.054 | 1.067 | 1.077 | 1.013 | .685 | 7.09 |
| Shadow 3 (Figure 116) | .996 | 1.018 | 1.020 | 1.027 | 1.031 | .857 | .142 | 7.54 |
| Shadow 4 (Figure 117) | .857 | .945 | .967 | .974 | .975 | .945 | .517 | 7.74 |

**-- Following the capacity check, a 84-ohm resistor is placed across the pack until the pack voltage is 7.00 volts.

d. Test results during the Shadow Periods: (Figures 118 and 119)

(1) End of Mid-Shadow Discharge Voltages: The average voltages have decreased from 1.204 (shadow 1) to 1.193 volts (shadow 4) with the largest decrease being 8 mv from shadow 1 to 2. There was a 3 mv difference between the high cell (6) and low cell (1) during the last shadow.

(2) Capacity/Reconditioning Effects: There has been a 9 percent increase in capacity from the capacity check performed prior to shadow 2 and the one prior to shadow 4, with cell 7 being the limiting cell. However, there has been a voltage degradation in that 98 percent of the total pack capacity was available above the 1.10 volt/cell average prior to shadow 2, 72 percent prior to shadow 3, and 63 percent prior to shadow 4. Only about 1 percent of the capacity is available below the 1.00 volt/cell average. The reconditioning effect, due to the daily discharges, is almost nonexistent except for an increase of 2 to 5 mv in the discharge voltages the last 4 to 5 days of each shadow.

(3) End of Mid-Shadow Charge Voltages and Pressures: The average voltages decreased 10 mv from shadow 1 to 2 as the charge current was increased from .26 to .325 amperes. The pressure (cell 6) also decreased from 32 to 28 psia. These voltages (1.436 volts) and pressure (26 psia) have remained constant the last two shadows with charge currents of .320 and .315 amperes. Cell 7 has exhibited the highest voltage, although it has never been more than 4 mv higher than the average.

e. Performance during Sun Periods: Pack began test with a sun period and has completed four sun periods with period 1 being only 2 months. The pressure has not exceeded 25 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period prior to the capacity check.

SUN PERIODS

| Voltages*** | 1 | | 2 | | 3 | | 4 | |
|-------------|--------------|-------------|-----------------|---------------|--------------|---------------|--------------|------------|
| | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.432 (6) | 1.443 (6) | 1.429 (6) | 1.433 (7) | 1.413 (1,6) | 1.430 (6,7) | 1.415 (7) | 1.433 (4) |
| Average | 1.431 | 1.442 | 1.428 | 1.431 | 1.412 | 1.428 | 1.414 | 1.432 |
| Low | 1.430 (1,2) | 1.441 (1,4) | 1.427 (1,2,3,5) | 1.430 (2,3,4) | 1.410 (4) | 1.427 (1,2,5) | 1.413 (2) | 1.430 (1) |

***--() indicates which cell

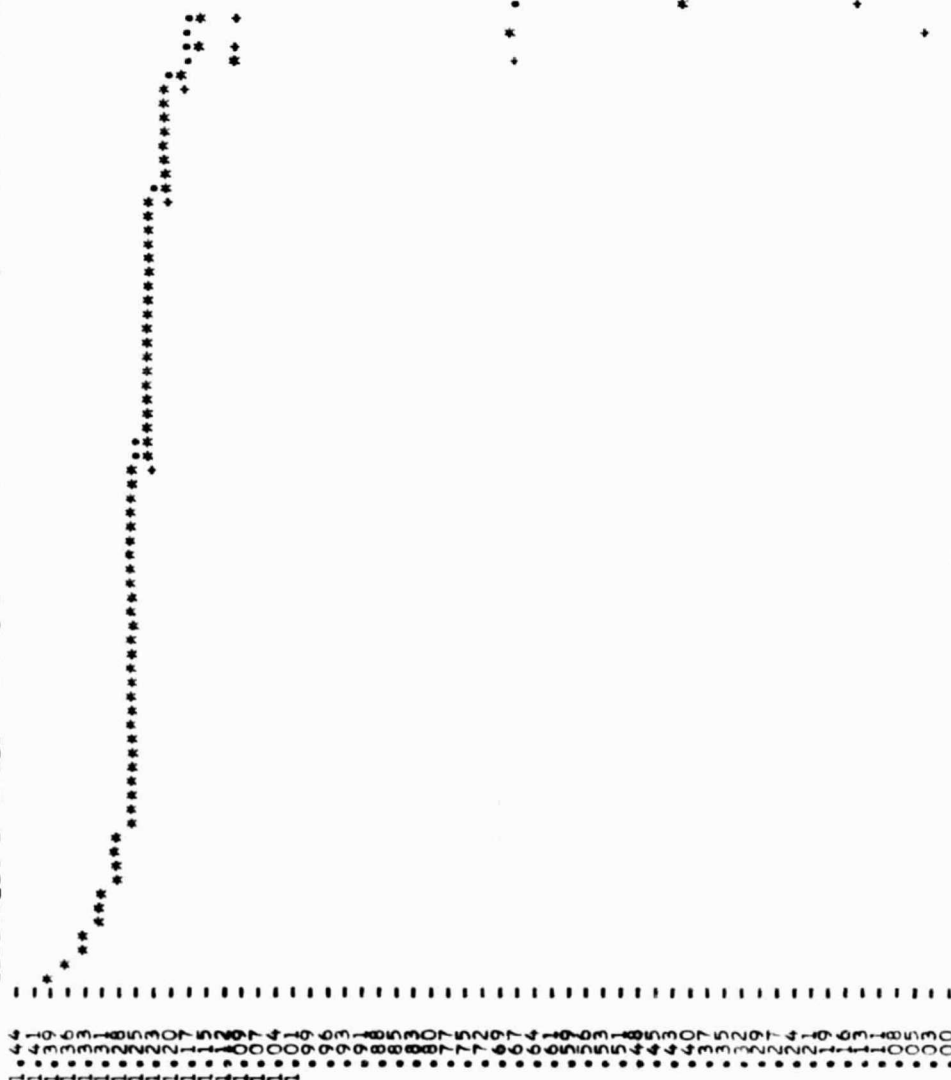
KEY HIGH CELL
+ LOW CELL
+ AVERAGE

PACK NUMBER IS 227D
PRE-CYCLING NUMBER IS 32
DISCHARGE RATE IS 2.61

AMPERE HOUR OUT

07 0.70 1.33 1.96 2.59 3.21 3.84 4.46 5.09 5.72 6.35 6.97 7.60
0.39 1.02 1.65 2.28 2.90 3.53 4.15 4.78 5.41 6.04 6.67 7.30 7.93

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102. 109. 116. 123. 130. 137. 144. 151. 158. 165. 172.

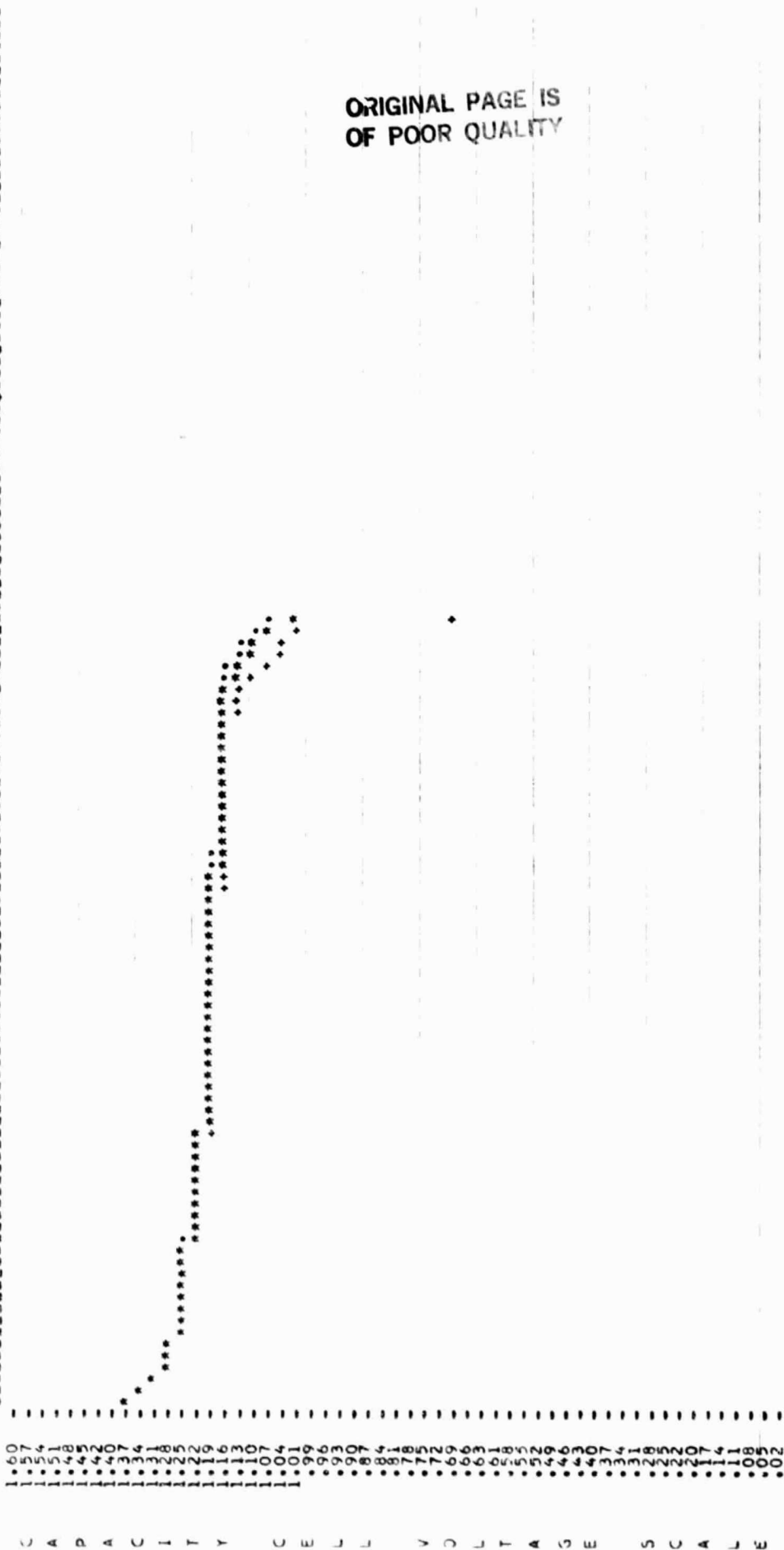
TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5 V-6 V-7

FIGURE 114

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ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER 45600 02
CYCLE NUMBER 136
DISCHARGE RATE 15 2.61
AMPERE HOUR OUT
05 37.69 1.32 1.95 2.58 3.21 3.84 4.47 5.10 5.73 6.36 6.99 7.09
1.00 1.63 2.26 2.89 3.52 4.15 4.78 5.41 6.04 6.67

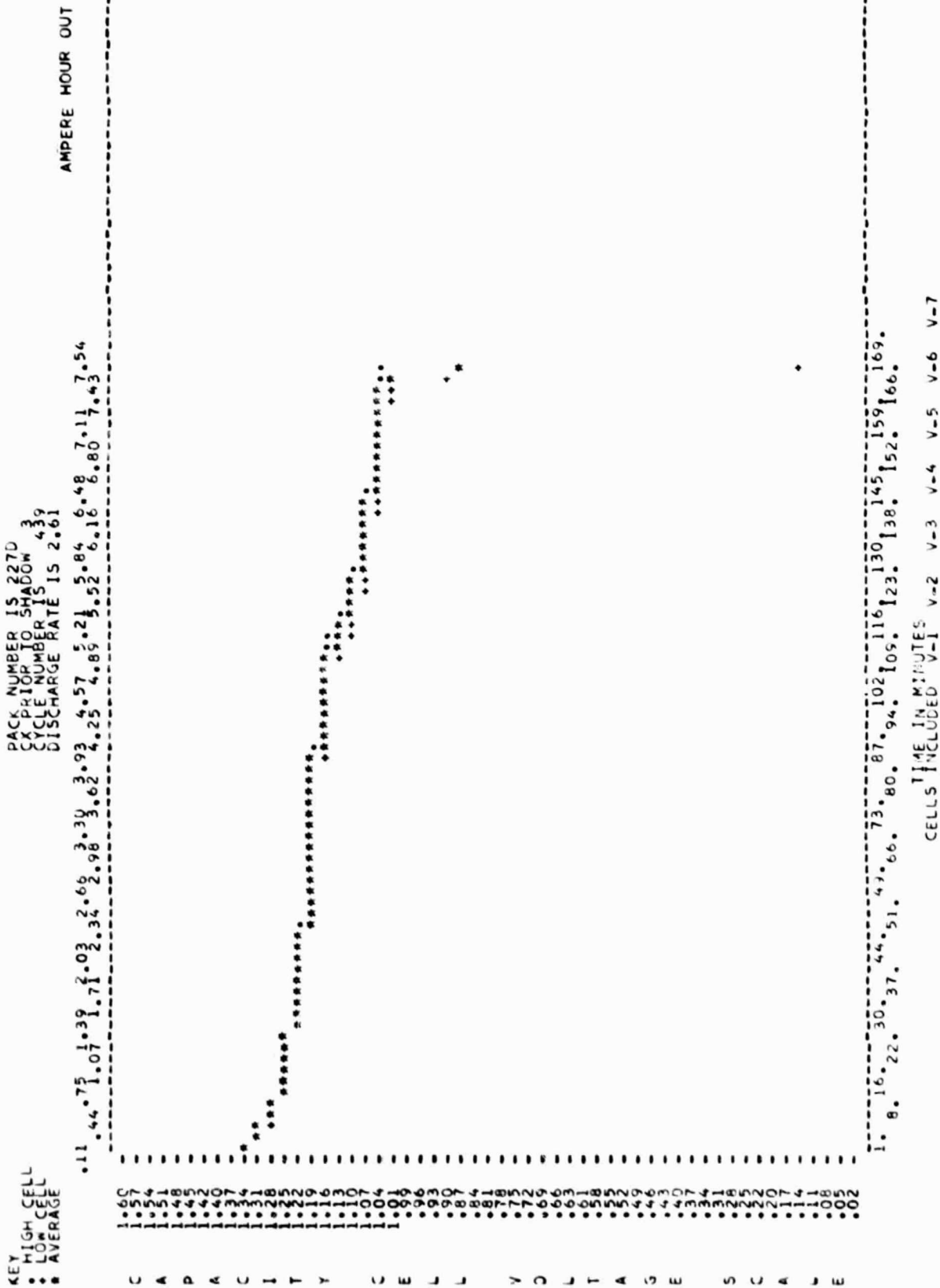


1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 74. 80. 87. 94. 102. 109. 116. 123. 130. 138. 145. 152. 159. 162.

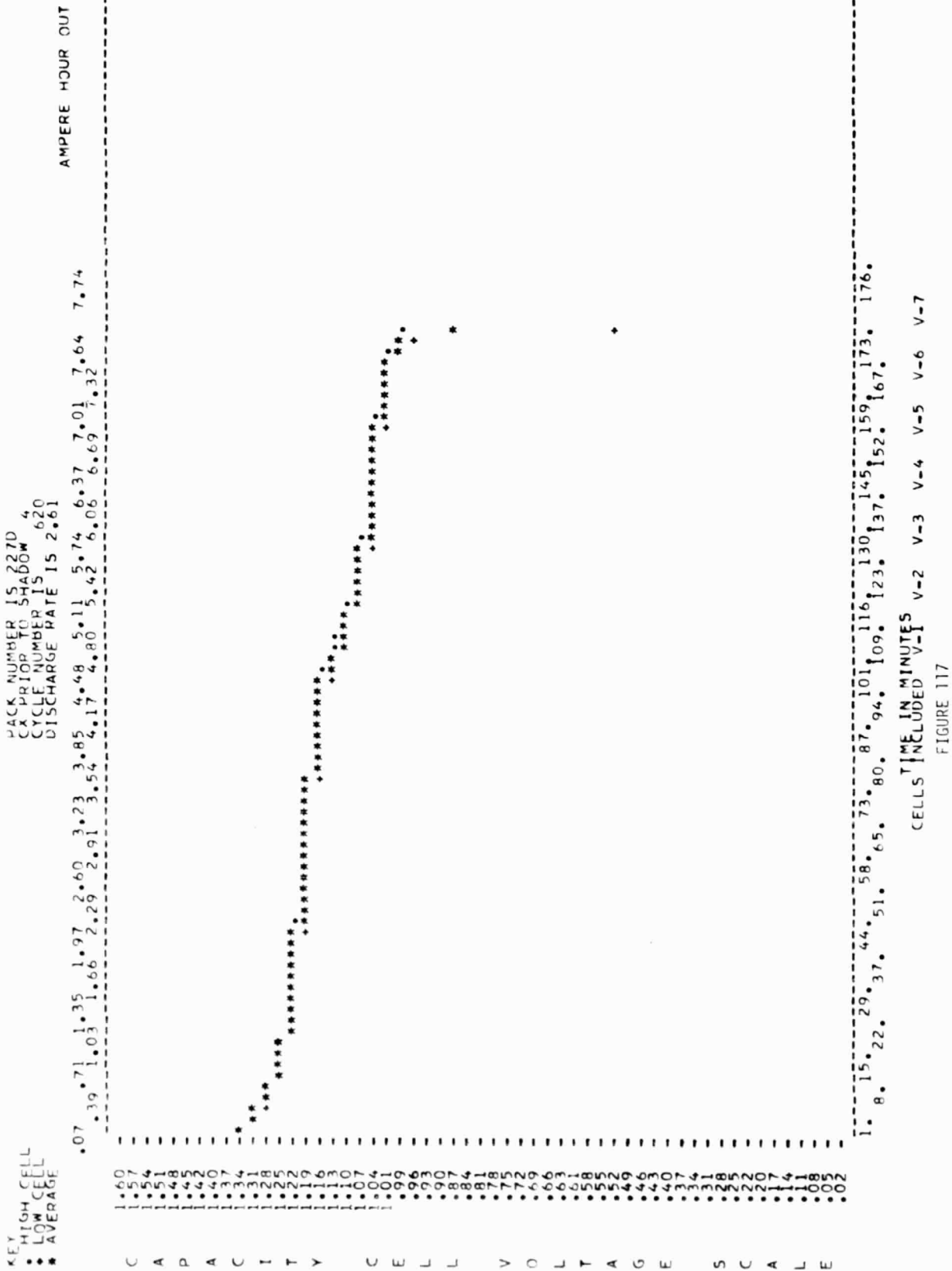
TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5 V-6 V-7

FIGURE 115

ORIGINAL PAGE IS
OF POOR QUALITY

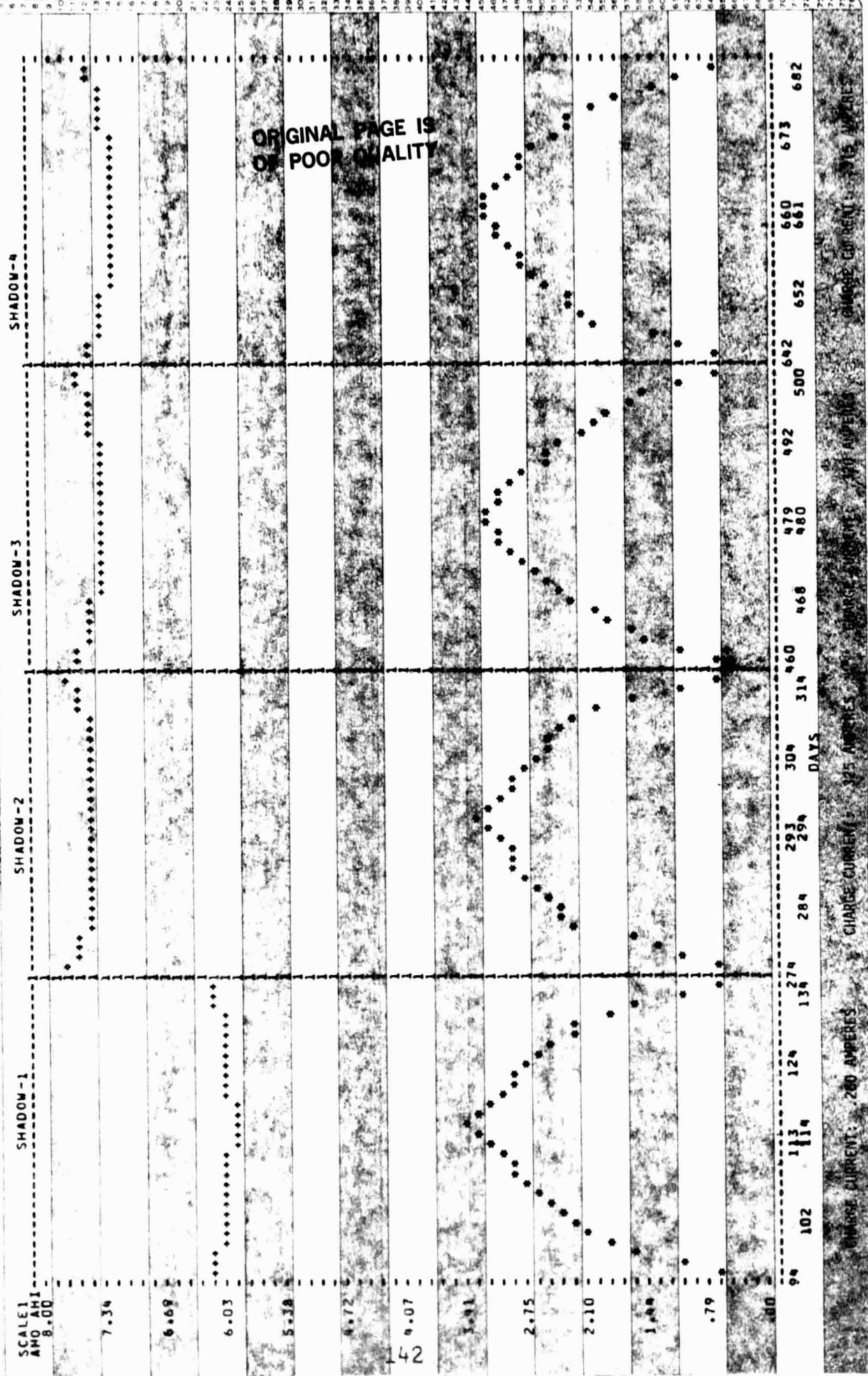


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SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 2270



2. Pack 227E, 5-cells, accelerated test - low rate

a. Cell information: (Same as Pack 227D, Section V.D.1. except no cells from HAC)

b. Parameters: (41-day shadow period, 1 week sun period)

| | | | |
|------------------------|-----|--------------------------|------|
| Depth of Discharge (%) | 52 | Discharge Current (amps) | 2.61 |
| Charge Control | CC | Temperature (°C) | 15 |
| Charge Current (amps)* | .26 | Float Current (amps) | .125 |

*-- Current was increased to .325 amps at the start of shadow 4. The current is decreased 5 ma for each succeeding shadow.

c. Capacity Check: **(Discharge to .75 volts any cell following each 4th shadow period.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah |
|-------------------------|------------------|------------------|------------------|------------------|------------------|------|
| Precycling (Figure 120) | 7.38 | 7.38 | 7.25 | 7.25 | 7.38 | |
| Shadow 4 (Figure 121) | .968 | 1.026 | .946 | .661 | .961 | 7.63 |
| Shadow 8 (Figure 122) | .893 | .974 | .528 | .756 | .886 | 7.57 |
| Shadow 12 (Figure 123) | .773 | .601 | .625 | .756 | .661 | 7.42 |

**-- Following the capacity check, a 60-ohm resistor is placed across the pack until the pack voltage is 5.00 volts.

d. Test results during the Shadow Periods: (Figures 124 to 129)

(1) End of Mid-Shadow Discharge Voltages: The average voltages decreased from shadows 1 to 4 (1.210 to 1.174 volts), shadows 5 to 8 (1.190 to 1.169 volts), and shadows 9 to 12 (1.188 to 1.169 volts). The pack was capacity checked following shadows 4 and 8 which accounts for the increase in voltage for shadows 5 and 9. The largest decrease was between shadows 1 and 2 (20 mv), shadows 5 and 6 (11 mv), and shadows 9 and 10 (11 mv). There was a 4 mv difference between the high cell (2) and the low cell (3) during the last shadow.

(2) Capacity/Reconditioning Effects: There has been a 3 percent decrease in capacity from the capacity check performed following shadow 4 to the one following shadow 12. However, there has been a voltage degradation in that 66 percent of the total pack capacity was available above the 1.10 volt/cell average following shadow 4 and 51 percent following shadow 12. Also, there was a decrease in the capacity available to the 1.00 volt/cell average from approximately 100 to 85 percent. The reconditioning effect, due to the daily discharges, is nonexistent the first shadow and the shadow following each capacity check; but is in evidence the other shadows with higher EOD voltages during the second half of each shadow.

(3) End of Mid-Shadow Charge Voltages: The voltages increased 10 mv from shadow 3 (1.431 volts) to 4 (1.441 volts) as the charge current was increased from .26 to .325 amperes. Although the charge current is decreased 5 ma each shadow, the change in voltages is very slight, if noticeable at all. The average voltage was 1.430 volts for shadows 6 to 8 and 1.432 volts for shadows 10 to 12 with slightly higher voltages during those shadows following the capacity checks. The cells have remained balanced with a maximum of 3 mv between the high and low cells. Enhancement of the EOD voltages or capacity is not evident due to the changing charge currents.

e. Performance during Sun Periods: Pack has completed 12, 1-week sun periods as it began test with a shadow period. The average voltage at the end of these periods is 1.425 volts with an increase of 4 mv those periods in which the pack is capacity checked.

KEY HIGH CELL
+ LOW CELL
+ AVERAGE

PACK NUMBER IS 227E

DRY-CYCLING RATE IS 32

DISCHARGE RATE IS 2.61

AMPERE HOUR OUT

0.02 0.34 0.65 0.97 1.28 1.60 1.91 2.23 2.54 2.86 3.17 3.49 3.80 4.12 4.43 4.75 5.07 5.39 5.71 6.03 6.35 6.67 6.99 7.31 7.63 7.95 8.27 8.59 8.91 9.23 9.55 9.87 10.19 10.51 10.83 11.15 11.47 11.79 12.11 12.43 12.75 13.07 13.39 13.71 14.03 14.35 14.67 14.99 15.31 15.63 15.95 16.27 16.59 16.91 17.23 17.55 17.87 18.19 18.51 18.83 19.15 19.47 19.79 20.11 20.43 20.75 21.07 21.39 21.71 22.03 22.35 22.67 22.99 23.31 23.63 23.95 24.27 24.59 24.91 25.23 25.55 25.87 26.19 26.51 26.83 27.15 27.47 27.79 28.11 28.43 28.75 29.07 29.39 29.71 30.03 30.35 30.67 30.99 31.31 31.63 31.95 32.27 32.59 32.91 33.23 33.55 33.87 34.19 34.51 34.83 35.15 35.47 35.79 36.11 36.43 36.75 37.07 37.39 37.71 38.03 38.35 38.67 38.99 39.31 39.63 39.95 40.27 40.59 40.91 41.23 41.55 41.87 42.19 42.51 42.83 43.15 43.47 43.79 44.11 44.43 44.75 45.07 45.39 45.71 46.03 46.35 46.67 46.99 47.31 47.63 47.95 48.27 48.59 48.91 49.23 49.55 49.87 50.19 50.51 50.83 51.15 51.47 51.79 52.11 52.43 52.75 53.07 53.39 53.71 54.03 54.35 54.67 54.99 55.31 55.63 55.95 56.27 56.59 56.91 57.23 57.55 57.87 58.19 58.51 58.83 59.15 59.47 59.79 60.11 60.43 60.75 61.07 61.39 61.71 62.03 62.35 62.67 62.99 63.31 63.63 63.95 64.27 64.59 64.91 65.23 65.55 65.87 66.19 66.51 66.83 67.15 67.47 67.79 68.11 68.43 68.75 69.07 69.39 69.71 70.03 70.35 70.67 70.99 71.31 71.63 71.95 72.27 72.59 72.91 73.23 73.55 73.87 74.19 74.51 74.83 75.15 75.47 75.79 76.11 76.43 76.75 77.07 77.39 77.71 78.03 78.35 78.67 78.99 79.31 79.63 79.95 80.27 80.59 80.91 81.23 81.55 81.87 82.19 82.51 82.83 83.15 83.47 83.79 84.11 84.43 84.75 85.07 85.39 85.71 86.03 86.35 86.67 86.99 87.31 87.63 87.95 88.27 88.59 88.91 89.23 89.55 89.87 90.19 90.51 90.83 91.15 91.47 91.79 92.11 92.43 92.75 93.07 93.39 93.71 94.03 94.35 94.67 94.99 95.31 95.63 95.95 96.27 96.59 96.91 97.23 97.55 97.87 98.19 98.51 98.83 99.15 99.47 99.79 100.11 100.43 100.75 101.07 101.39 101.71 102.03 102.35 102.67 102.99 103.31 103.63 103.95 104.27 104.59 104.91 105.23 105.55 105.87 106.19 106.51 106.83 107.15 107.47 107.79 108.11 108.43 108.75 109.07 109.39 109.71 110.03 110.35 110.67 110.99 111.31 111.63 111.95 112.27 112.59 112.91 113.23 113.55 113.87 114.19 114.51 114.83 115.15 115.47 115.79 116.11 116.43 116.75 117.07 117.39 117.71 118.03 118.35 118.67 118.99 119.31 119.63 119.95 120.27 120.59 120.91 121.23 121.55 121.87 122.19 122.51 122.83 123.15 123.47 123.79 124.11 124.43 124.75 125.07 125.39 125.71 126.03 126.35 126.67 126.99 127.31 127.63 127.95 128.27 128.59 128.91 129.23 129.55 129.87 130.19 130.51 130.83 131.15 131.47 131.79 132.11 132.43 132.75 133.07 133.39 133.71 134.03 134.35 134.67 134.99 135.31 135.63 135.95 136.27 136.59 136.91 137.23 137.55 137.87 138.19 138.51 138.83 139.15 139.47 139.79 140.11 140.43 140.75 141.07 141.39 141.71 142.03 142.35 142.67 142.99 143.31 143.63 143.95 144.27 144.59 144.91 145.23 145.55 145.87 146.19 146.51 146.83 147.15 147.47 147.79 148.11 148.43 148.75 149.07 149.39 149.71 150.03 150.35 150.67 150.99 151.31 151.63 151.95 152.27 152.59 152.91 153.23 153.55 153.87 154.19 154.51 154.83 155.15 155.47 155.79 156.11 156.43 156.75 157.07 157.39 157.71 158.03 158.35 158.67 158.99 159.31 159.63 159.95 160.27 160.59 160.91 161.23 161.55 161.87 162.19 162.51 162.83 163.15 163.47 163.79 164.11 164.43 164.75 165.07 165.39 165.71 166.03 166.35 166.67 166.99 167.31 167.63 167.95 168.27 168.59 168.91 169.23 169.55 169.87 170.19 170.51 170.83 171.15 171.47 171.79 172.11 172.43 172.75 173.07 173.39 173.71 174.03 174.35 174.67 174.99 175.31 175.63 175.95 176.27 176.59 176.91 177.23 177.55 177.87 178.19 178.51 178.83 179.15 179.47 179.79 180.11 180.43 180.75 181.07 181.39 181.71 182.03 182.35 182.67 182.99 183.31 183.63 183.95 184.27 184.59 184.91 185.23 185.55 185.87 186.19 186.51 186.83 187.15 187.47 187.79 188.11 188.43 188.75 189.07 189.39 189.71 190.03 190.35 190.67 190.99 191.31 191.63 191.95 192.27 192.59 192.91 193.23 193.55 193.87 194.19 194.51 194.83 195.15 195.47 195.79 196.11 196.43 196.75 197.07 197.39 197.71 198.03 198.35 198.67 198.99 199.31 199.63 199.95 200.27 200.59 200.91 201.23 201.55 201.87 202.19 202.51 202.83 203.15 203.47 203.79 204.11 204.43 204.75 205.07 205.39 205.71 206.03 206.35 206.67 206.99 207.31 207.63 207.95 208.27 208.59 208.91 209.23 209.55 209.87 210.19 210.51 210.83 211.15 211.47 211.79 212.11 212.43 212.75 213.07 213.39 213.71 214.03 214.35 214.67 214.99 215.31 215.63 215.95 216.27 216.59 216.91 217.23 217.55 217.87 218.19 218.51 218.83 219.15 219.47 219.79 220.11 220.43 220.75 221.07 221.39 221.71 222.03 222.35 222.67 222.99 223.31 223.63 223.95 224.27 224.59 224.91 225.23 225.55 225.87 226.19 226.51 226.83 227.15 227.47 227.79 228.11 228.43 228.75 229.07 229.39 229.71 230.03 230.35 230.67 230.99 231.31 231.63 231.95 232.27 232.59 232.91 233.23 233.55 233.87 234.19 234.51 234.83 235.15 235.47 235.79 236.11 236.43 236.75 237.07 237.39 237.71 238.03 238.35 238.67 238.99 239.31 239.63 239.95 240.27 240.59 240.91 241.23 241.55 241.87 242.19 242.51 242.83 243.15 243.47 243.79 244.11 244.43 244.75 245.07 245.39 245.71 246.03 246.35 246.67 246.99 247.31 247.63 247.95 248.27 248.59 248.91 249.23 249.55 249.87 250.19 250.51 250.83 251.15 251.47 251.79 252.11 252.43 252.75 253.07 253.39 253.71 254.03 254.35 254.67 254.99 255.31 255.63 255.95 256.27 256.59 256.91 257.23 257.55 257.87 258.19 258.51 258.83 259.15 259.47 259.79 260.11 260.43 260.75 261.07 261.39 261.71 262.03 262.35 262.67 262.99 263.31 263.63 263.95 264.27 264.59 264.91 265.23 265.55 265.87 266.19 266.51 266.83 267.15 267.47 267.79 268.11 268.43 268.75 269.07 269.39 269.71 270.03 270.35 270.67 270.99 271.31 271.63 271.95 272.27 272.59 272.91 273.23 273.55 273.87 274.19 274.51 274.83 275.15 275.47 275.79 276.11 276.43 276.75 277.07 277.39 277.71 278.03 278.35 278.67 278.99 279.31 279.63 279.95 280.27 280.59 280.91 281.23 281.55 281.87 282.19 282.51 282.83 283.15 283.47 283.79 284.11 284.43 284.75 285.07 285.39 285.71 286.03 286.35 286.67 286.99 287.31 287.63 287.95 288.27 288.59 288.91 289.23 289.55 289.87 290.19 290.51 290.83 291.15 291.47 291.79 292.11 292.43 292.75 293.07 293.39 293.71 294.03 294.35 294.67 294.99 295.31 295.63 295.95 296.27 296.59 296.91 297.23 297.55 297.87 298.19 298.51 298.83 299.15 299.47 299.79 300.11 300.43 300.75 301.07 301.39 301.71 302.03 302.35 302.67 302.99 303.31 303.63 303.95 304.27 304.59 304.91 305.23 305.55 305.87 306.19 306.51 306.83 307.15 307.47 307.79 308.11 308.43 308.75 309.07 309.39 309.71 310.03 310.35 310.67 310.99 311.31 311.63 311.95 312.27 312.59 312.91 313.23 313.55 313.87 314.19 314.51 314.83 315.15 315.47 315.79 316.11 316.43 316.75 317.07 317.39 317.71 318.03 318.35 318.67 318.99 319.31 319.63 319.95 320.27 320.59 320.91 321.23 321.55 321.87 322.19 322.51 322.83 323.15 323.47 323.79 324.11 324.43 324.75 325.07 325.39 325.71 326.03 326.35 326.67 326.99 327.31 327.63 327.95 328.27 328.59 328.91 329.23 329.55 329.87 330.19 330.51 330.83 331.15 331.47 331.79 332.11 332.43 332.75 333.07 333.39 333.71 334.03 334.35 334.67 334.99 335.31 335.63 335.95 336.27 336.59 336.91 337.23 337.55 337.87 338.19 338.51 338.83 339.15 339.47 339.79 340.11 340.43 340.75 341.07 341.39 341.71 342.03 342.35 342.67 342.99 343.31 343.63 343.95 344.27 344.59 344.91 345.23 345.55 345.87 346.19 346.51 346.83 347.15 347.47 347.79 348.11 348.43 348.75 349.07 349.39 349.71 350.03 350.35 350.67 350.99 351.31 351.63 351.95 352.27 352.59 352.91 353.23 353.55 353.87 354.19 354.51 354.83 355.15 355.47 355.79 356.11 356.43 356.75 357.07 357.39 357.71 358.03 358.35 358.67 358.99 359.31 359.63 359.95 360.27 360.59 360.91 361.23 361.55 361.87 362.19 362.51 362.83 363.15 363.47 363.79 364.11 364.43 364.75 365.07 365.39 365.71 366.03 366.35 366.67 366.99 367.31 367.63 367.95 368.27 368.59 368.91 369.23 369.55 369.87 370.19 370.51 370.83 371.15 371.47 371.79 372.11 372.43 372.75 373.07 373.39 373.71 374.03 374.35 374.67 374.99 375.31 375.63 375.95 376.27 376.59 376.91 377.23 377.55 377.87 378.19 378.51 378.83 379.15 379.47 379.79 380.11 380.43 380.75 381.07 381.39 381.71 382.03 382.35 382.67 382.99 383.31 383.63 383.95 384.27 384.59 384.91 385.23 385.55 385.87 386.19 386.51 386.83 387.15 387.47 387.79 388.11 388.43 388.75 389.07 389.39 389.71 390.03 390.35 390.67 390.99 391.31 391.63 391.95 392.27 392.59 392.91 393.23 393.55 393.87 394.19 394.51 394.83 395.15 395.47 395.79 396.11 396.43 396.75 397.07 397.39 397.71 398.03 398.35 398.67 398.99 399.31 399.63 399.95 400.27 400.59 400.91 401.23 401.55 401.87 402.19 402.51 402.83 403.15 403.47 403.79 404.11 404.43 404.75 405.07 405.39 405.71 406.03 406.35 406.67 406.99 407.31 407.63 407.95 408.27 408.59 408.91 409.23 409.55 409.87 410.19 410.51 410.83 411.15 411.47 411.79 412.11 412.43 412.75 413.07 413.39 413.71 414.03 414.35 414.67 414.99 415.31 415.63 415.95 416.27 416.59 416.91 417.23 417.55 417.87 418.19 418.51 418.83 419.15 419.47 419.79 420.11 420.43 420.75 421.07 421.39 421.71 422.03 422.35 422.67 422.99 423.31 423.63 423.95 424.27 424.59 424.91 425.23 425.55 425.87 426.19 426.51 426.83 427.15 427.47 427.79 428.11 428.43 428.75 429.07 429.39 429.71 430.03 430.35 430.67 430.99 431.31 431.63 431.95 432.27 432.59 432.91 433.23 433.55 433.87 434.19 434.51 434.83 435.15 435.47 435.79 436.11 436.43 436.75 437.07 437.39 437.71 438.03 438.35 438.67 438.99 439.31 439.63 439.95 440.27 440.59 440.91 441.23 441.55 441.87 442.19 442.51 442.83 443.15 443.47 443.79 444.11 444.43 444.75 445.07 445.39 445.71 446.03 446.35 446.67 446.99 447.31 447.63 447.95 448.27 448.59 448.91 449.23 449.55 449.87 450.19 450.51 450.83 451.15 451.47 451.79 452.11 452.43 452.75 453.07 453.39 453.71 454.03 454.35 454.67 454.99 455.31 455.63 455.95 456.27 456.59 456.91 457.23 457.55 457.87 458.19 458.51 458.83 459.15 459.47 459.79 460.11 460.43 460.75 461.07 461.39 461.71 462.03 462.35 462.67 462.99 463.31 463.63 463.95 464.27 464.59 464.91 465.23 465.55 465.87 466.19 466.51 466.83 467.15 467.47 467.79 468.11 468.43 468.75 469.07 469.39 469.71 470.03 470.35 470.67 470.99 471.31 471.63 471.95 472.27 472.59 472.91 473.23 473.55 473.87 474.19 474.51 474.83 475.15 475.47 475.79 476.11 476.43 476.75 477.07 477.39 477.71 478.03 478.35 478.67 478.99 479.31 479.63 479.95 480.27 480.59 480.91 481.23 481.55 481.87 482.19 482.51 482.83 483.15 483.47 483.79 484.11 484.43 484.75 485.07 485.39 485.71 486.03 486.35 486.67 486.99 487.31 487.63 487.95 488.27 488.59 488.91 489.23 489.55 489.87 490.19 490.51 490.83 491.15 491.47 491.79 492.11 492.43 492.75 493.07 493.39 493.71 494.03 494.35 494.67 494.99 495.31 495.63 495.95 496.27 496.59 496.91 497.23 497.55 497.87 498.19 498.51 498.83 499.15 499.47 499.79 500.11 500.43 500.75 501.07 501.39 501.71 502.03 502.35 502.67 502.99 503.31 503.63 503.95 504.27 504.59 504.91 505.23 505.55 505.87 506.19 506.51 506.83 507.15 507.47 507.79 508.11 508.43 508.75 509.07 509.39 509.71 510.03 510.35 510.67 510.99 511.31 511.63 511.95 512.27 512.59 512.91 513.23 513.55 513.87 514.19 514.51 514.83 515.15 515.47 515.79 516.11 516.43 516.75 517.07 517.39 517.71 518.03 518.35 518.67 518.99 519.31 519.63 519.95 520.27 520.59 520.91 521.23 521.55 521.87 522.19 522.51 522.83 523.15 523.47 523.79 524.11 524.43 524.75 525.07 525.39 525.71 526.03 526.35 526.67 526.99 527.31 527.63 527.95 528.27 528.59 528.91 529.23 529.55 529.87 530.19 530.51 530.83 531.15 531.47 531.79 532.11 532.43 532.75 533.07 533.39 533.71 534.03 534.35 534.67 534.99 535.31 535.63 535.95 536.27 536.59 536.91 537.23 537.55 537.87 538.19 538.51 538.83 539.15 539.47 539.79 540.11 540.43 540.75 541.07 541.39 541.71 542.03 542.35 542.67 542.99 543.31 543.63 543.95 544.27 544.59 544.91 545.23 545.55 545.87 546.19 546.51 546.83 547.15 547.47 547.79 548.11 548.43 548.75 549.07 549.39 549.71 550.03 550.35 550.67 550.99 551.31 551.63 551.95 552.27 552.59 552.91 553.23 553.55 553.87 554.19 554.51 554.83 555.15 555.47 555.79 556.11 556.43 556.75 557.07 557.39 557.71 558.03 558.35 558.67 558.99 559.31 559.63 559.95 560.27 560.59 560.91 561.23 561.55 561.87 562.19 562.51 562.83 563.15 563.47 563.79 564.11 564.43 564.75 565.07 565.39 565.71 566.03 566.35 566.67 566.99 567.31 5

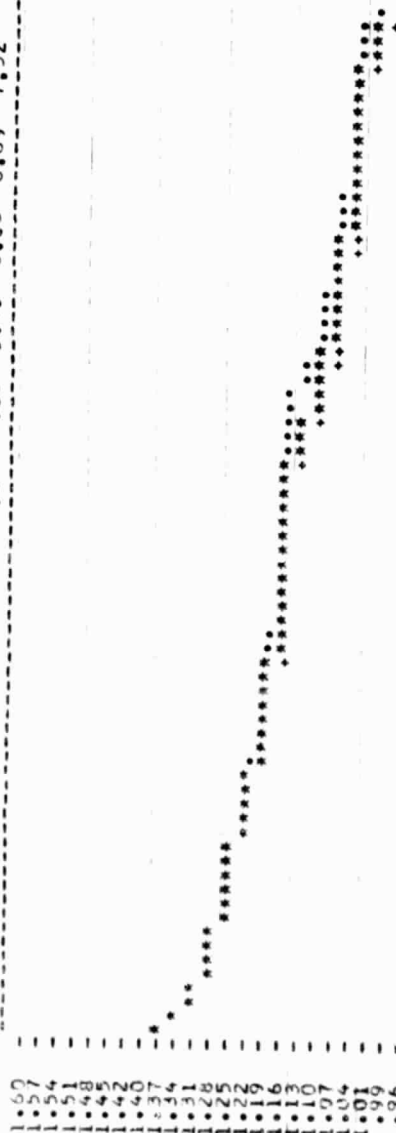
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

BACK NUMBER 13887E
 RECORD AFTER SHADOW 4
 CYCLE NUMBER 241
 DISCHARGE RATE IS 2.61

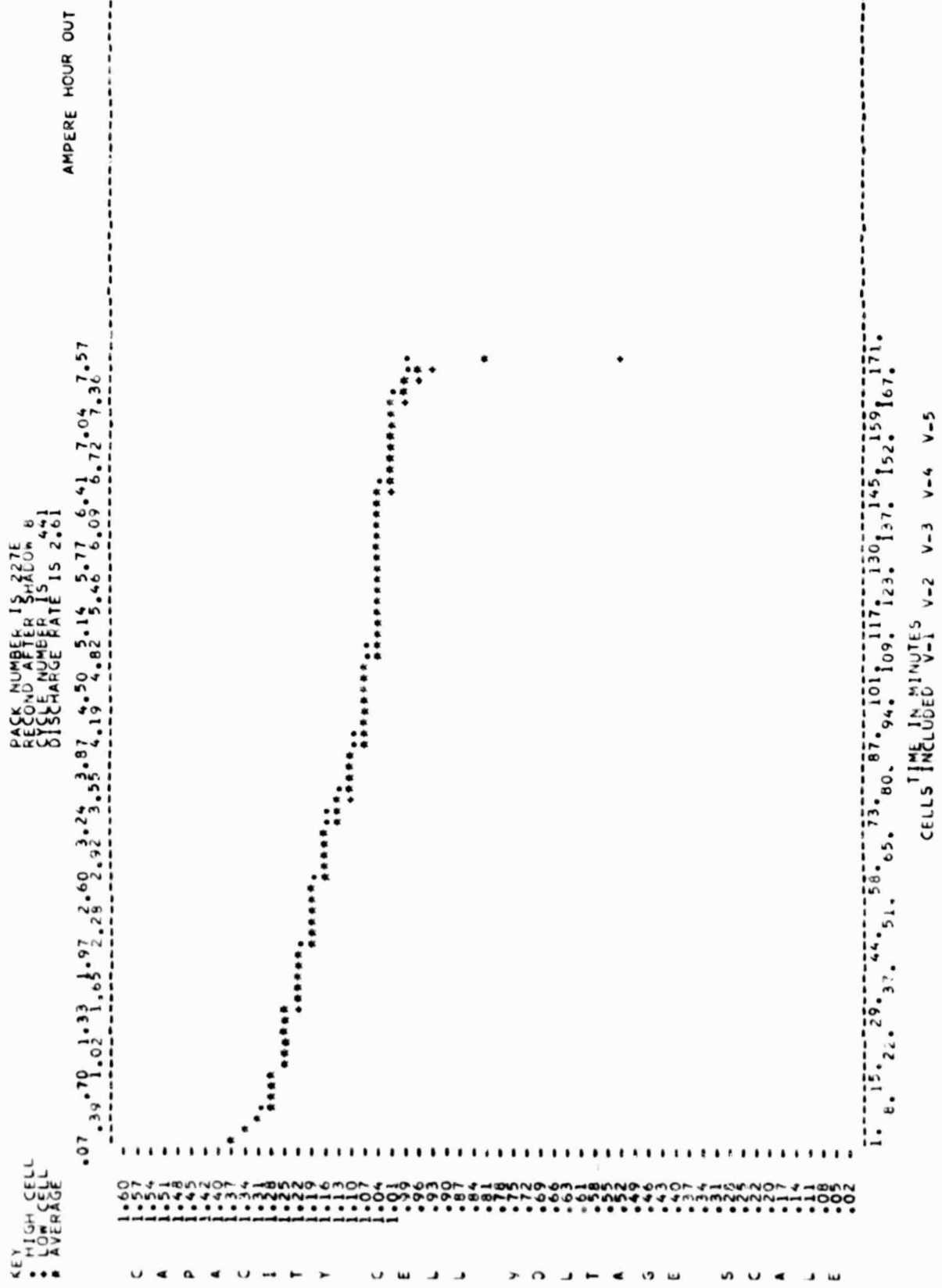
AMPERE HOUR OUT

07 1.70 1.33 1.94 2.59 3.22 3.85 4.48 5.11 5.74 6.37 7.00 7.63
 39 1.02 1.65 2.28 2.91 3.54 4.17 4.80 5.43 6.06 6.69 7.32

C
 A
 P
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ORIGINAL PAGE IS
OF POOR QUALITY



ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 227E
RECORD AFTER SHADOW 12
CYCLE NUMBER IS 642
DISCHARGE RATE IS 2.61

AMPERE HOUR 011

0.07 0.39 1.02 1.33 1.96 2.28 2.91 3.22 3.85 4.48 5.11 5.74 6.37 7.00 7.42
1.62 2.28 2.91 3.54 4.17 4.80 5.43 6.06 6.69 7.32

KEY HIGH CELL
+ LOW CELL
• AVERAGE

C 1.67
A 1.54
P 1.51
A 1.48
C 1.40
I 1.37
T 1.34
Y 1.28
C 1.25
E 1.22
L 1.19
L 1.16
V 1.13
O 1.10
L 1.07
T 1.04
A 1.01
C 0.99
E 0.96
S 0.93
C 0.90
A 0.87
L 0.84
E 0.81
S 0.78
C 0.75
A 0.72
L 0.69
E 0.66
S 0.63
C 0.61
A 0.58
L 0.55
E 0.52
S 0.49
C 0.46
A 0.43
L 0.40
E 0.37
S 0.34
C 0.31
A 0.28
L 0.25
E 0.22
S 0.19
C 0.16
A 0.13
L 0.10
E 0.07

1. 9. 16. 24. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102. 109. 117. 124. 131. 138. 145. 153. 160. 167. 169.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 123

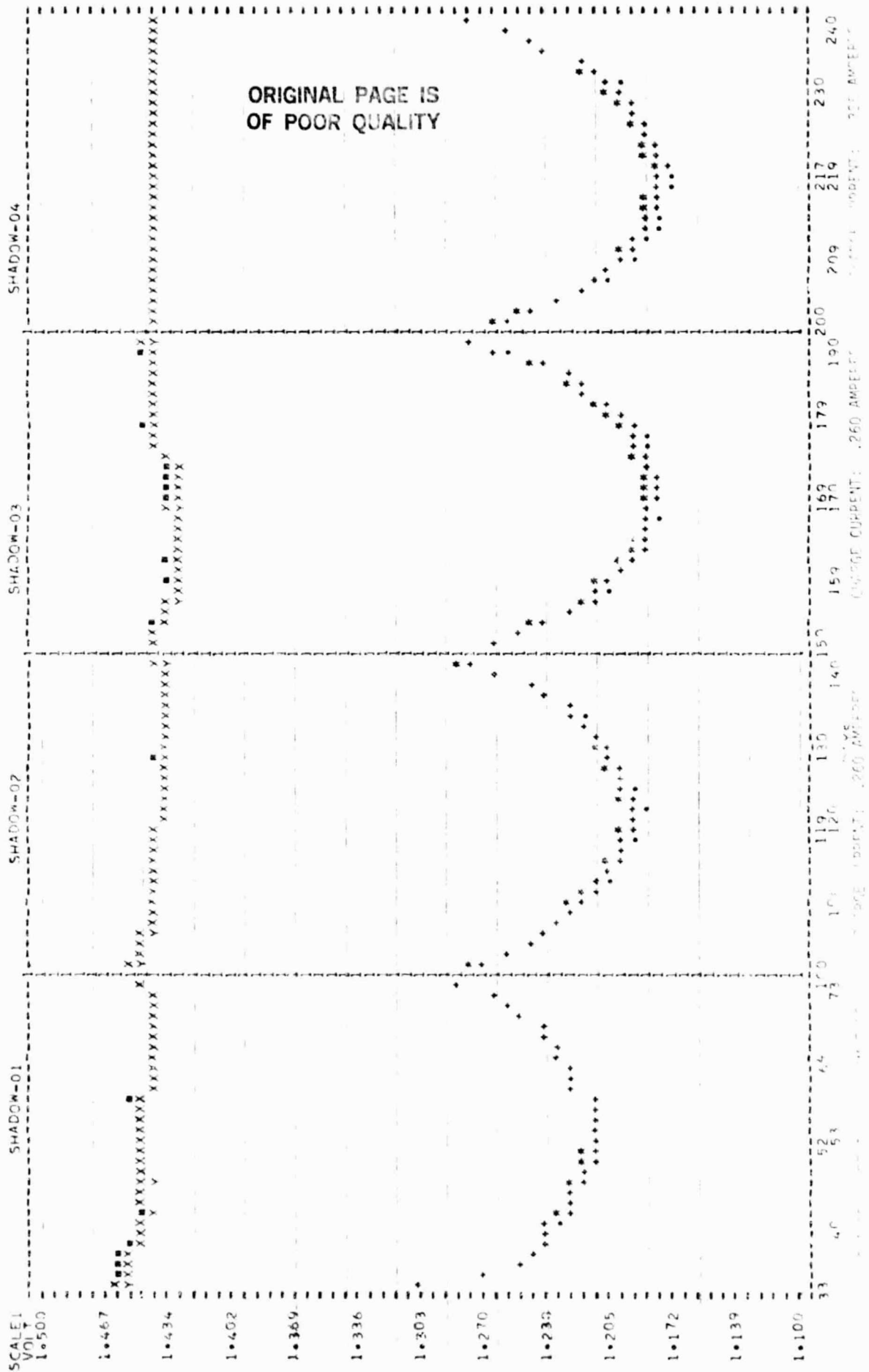
KEY
 * HIGH
 * END
 * DISCHARGE VOLTAGE
 * AVE
 * END
 * DISCHARGE VOLTAGE
 * LOW
 * END
 * DISCHARGE VOLTAGE
 * HIGH
 * EOC
 * AVE
 * EOC
 * LOW
 * EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52
 TEMPERATURE 15
 AMPERE RATE 10
 GENERAL ELECTRIC CELLS

SERIAL 016 055 072 073 074
 GOES D & F AND F

PACK = 227E



| | TIME | END | DISCHARGE | VOLTAGE |
|----|------|------|-----------|---------|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 0.00 | 0.00 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29 | 0.00 | 0.00 | 0.00 | 0.00 |
| 30 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 0.00 | 0.00 | 0.00 | 0.00 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.00 | 0.00 | 0.00 | 0.00 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 |
| 37 | 0.00 | 0.00 | 0.00 | 0.00 |
| 38 | 0.00 | 0.00 | 0.00 | 0.00 |
| 39 | 0.00 | 0.00 | 0.00 | 0.00 |
| 40 | 0.00 | 0.00 | 0.00 | 0.00 |
| 41 | 0.00 | 0.00 | 0.00 | 0.00 |
| 42 | 0.00 | 0.00 | 0.00 | 0.00 |
| 43 | 0.00 | 0.00 | 0.00 | 0.00 |
| 44 | 0.00 | 0.00 | 0.00 | 0.00 |
| 45 | 0.00 | 0.00 | 0.00 | 0.00 |
| 46 | 0.00 | 0.00 | 0.00 | 0.00 |
| 47 | 0.00 | 0.00 | 0.00 | 0.00 |
| 48 | 0.00 | 0.00 | 0.00 | 0.00 |
| 49 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50 | 0.00 | 0.00 | 0.00 | 0.00 |
| 51 | 0.00 | 0.00 | 0.00 | 0.00 |
| 52 | 0.00 | 0.00 | 0.00 | 0.00 |
| 53 | 0.00 | 0.00 | 0.00 | 0.00 |
| 54 | 0.00 | 0.00 | 0.00 | 0.00 |
| 55 | 0.00 | 0.00 | 0.00 | 0.00 |
| 56 | 0.00 | 0.00 | 0.00 | 0.00 |
| 57 | 0.00 | 0.00 | 0.00 | 0.00 |
| 58 | 0.00 | 0.00 | 0.00 | 0.00 |
| 59 | 0.00 | 0.00 | 0.00 | 0.00 |
| 60 | 0.00 | 0.00 | 0.00 | 0.00 |
| 61 | 0.00 | 0.00 | 0.00 | 0.00 |
| 62 | 0.00 | 0.00 | 0.00 | 0.00 |
| 63 | 0.00 | 0.00 | 0.00 | 0.00 |
| 64 | 0.00 | 0.00 | 0.00 | 0.00 |
| 65 | 0.00 | 0.00 | 0.00 | 0.00 |
| 66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 67 | 0.00 | 0.00 | 0.00 | 0.00 |
| 68 | 0.00 | 0.00 | 0.00 | 0.00 |
| 69 | 0.00 | 0.00 | 0.00 | 0.00 |
| 70 | 0.00 | 0.00 | 0.00 | 0.00 |
| 71 | 0.00 | 0.00 | 0.00 | 0.00 |
| 72 | 0.00 | 0.00 | 0.00 | 0.00 |
| 73 | 0.00 | 0.00 | 0.00 | 0.00 |
| 74 | 0.00 | 0.00 | | |

SERIAL 016 055 072 073 074
GOES D.E AND F

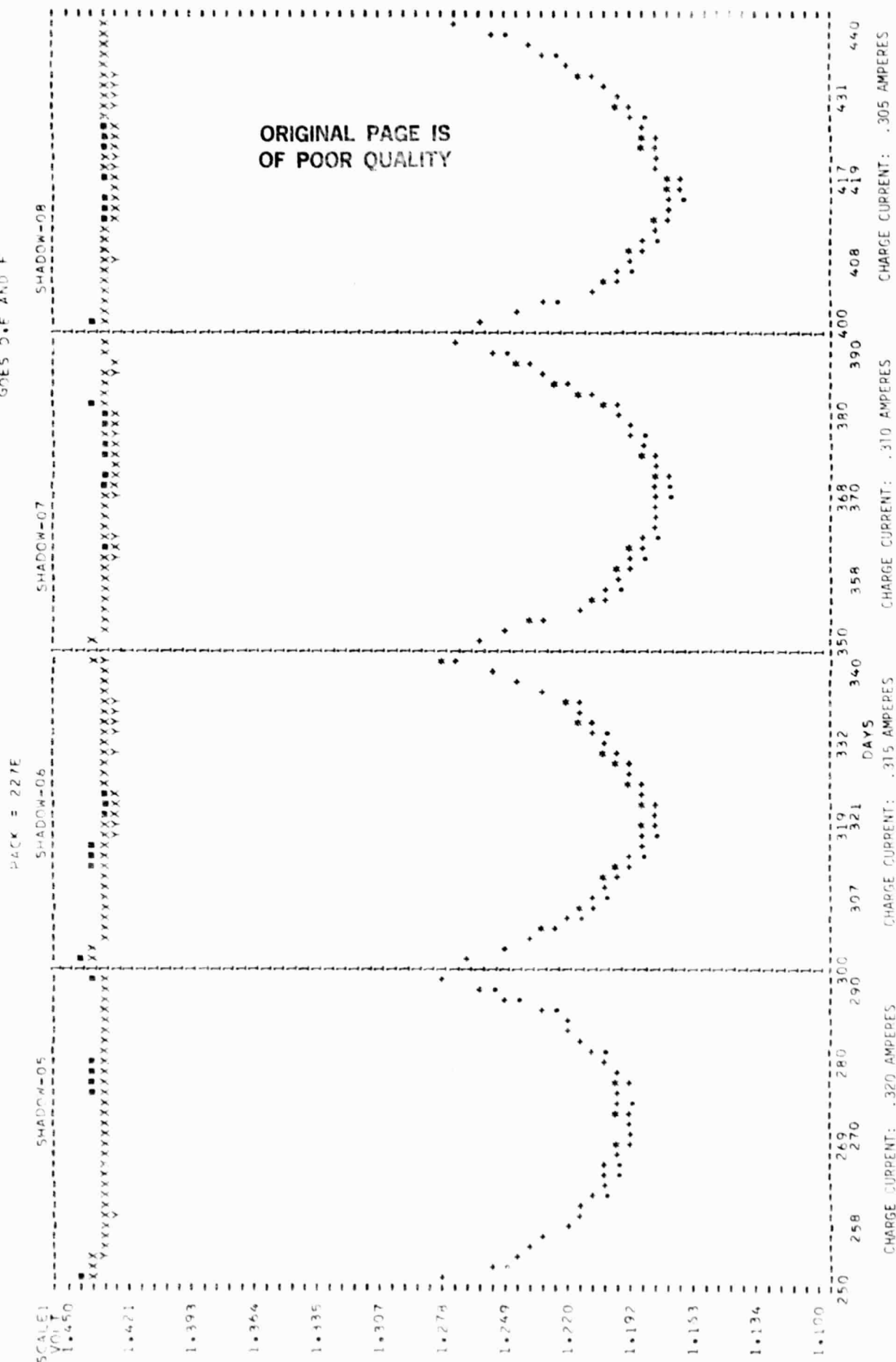


FIGURE 125

MOEC/C 81-120A

DEPTH DISCHARGE 52
TEMPERATURE 15
AMPERE RATE 06
GENERAL ELECTRIC CELLS

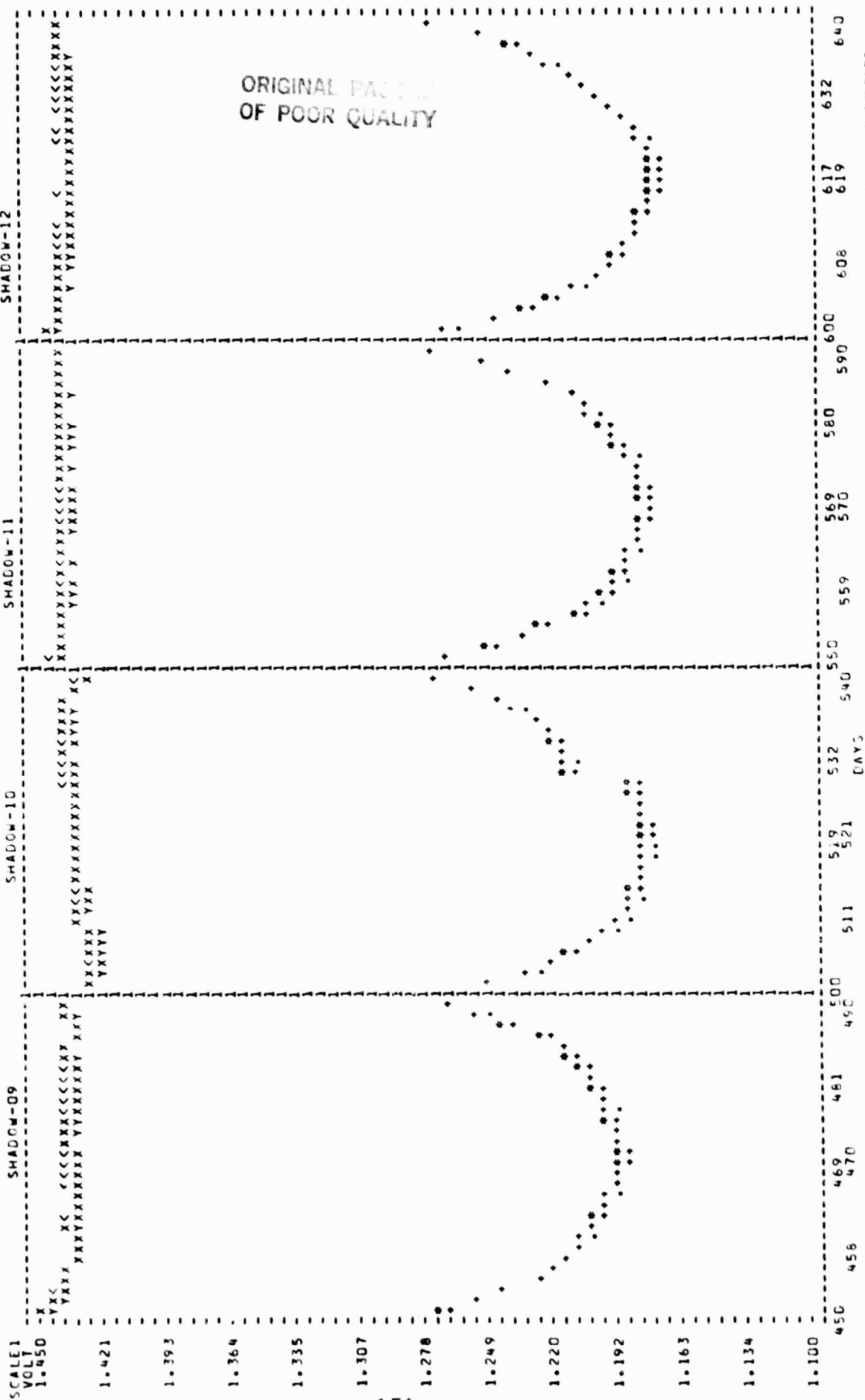
SERIAL 016 055 072 073 074

GOES D,E AND F

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
• HIGH END DISCHARGE VOLTAGE
• AVE END DISCHARGE VOLTAGE
• LOW END DISCHARGE VOLTAGE
• HIGH EOC
• AVE EOC
• LOW EOC

PACK = 227E



KEY
 * AHO
 * AWT-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52 WOEC/C 81-120A
 TEMPERATURE 15
 AMPERE RATE 06
 GENERAL ELECTRIC CELLS
 SERIAL 016 055 072 073 074
 GOES D, E AND F

PACK = 227E

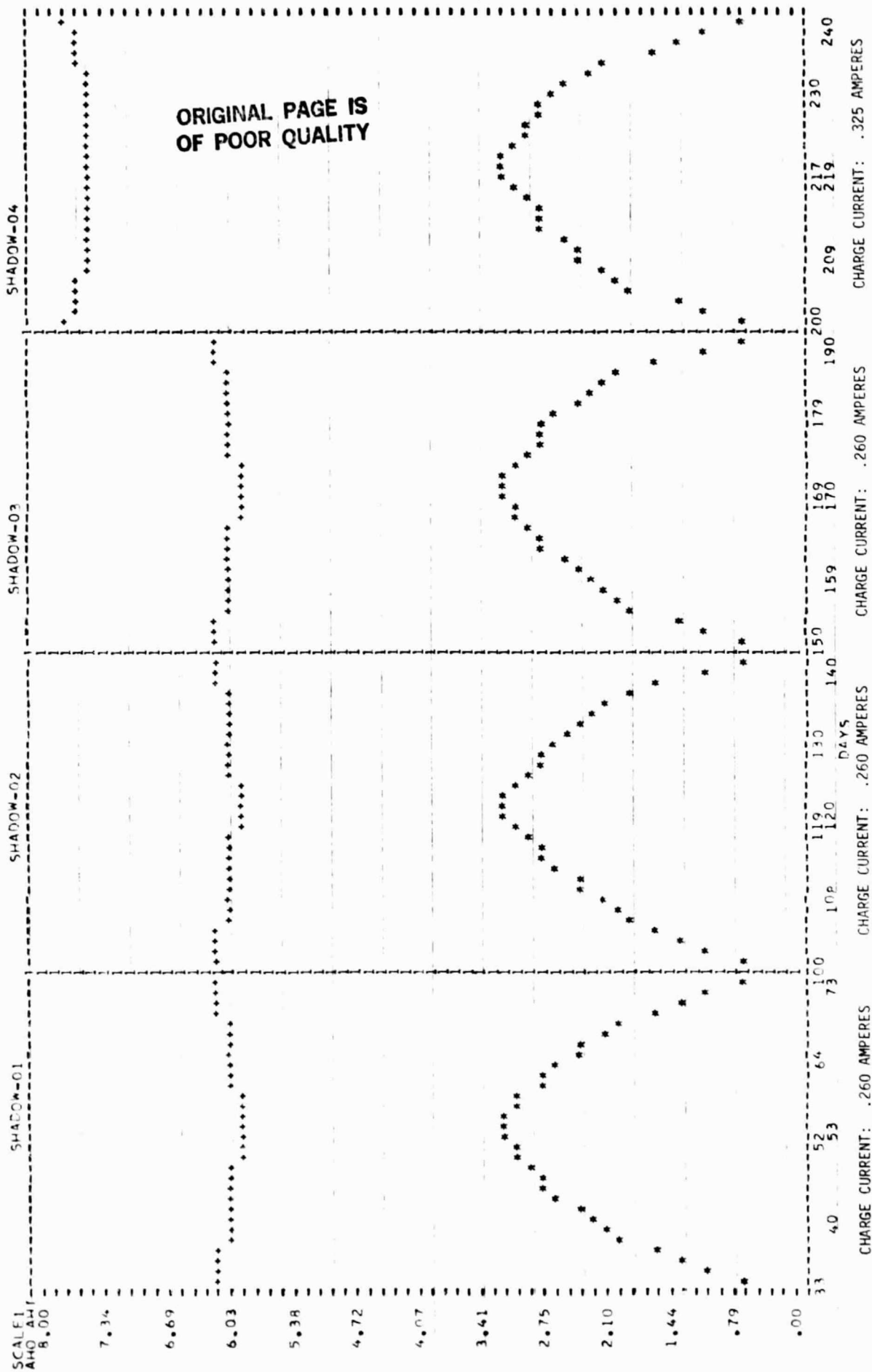


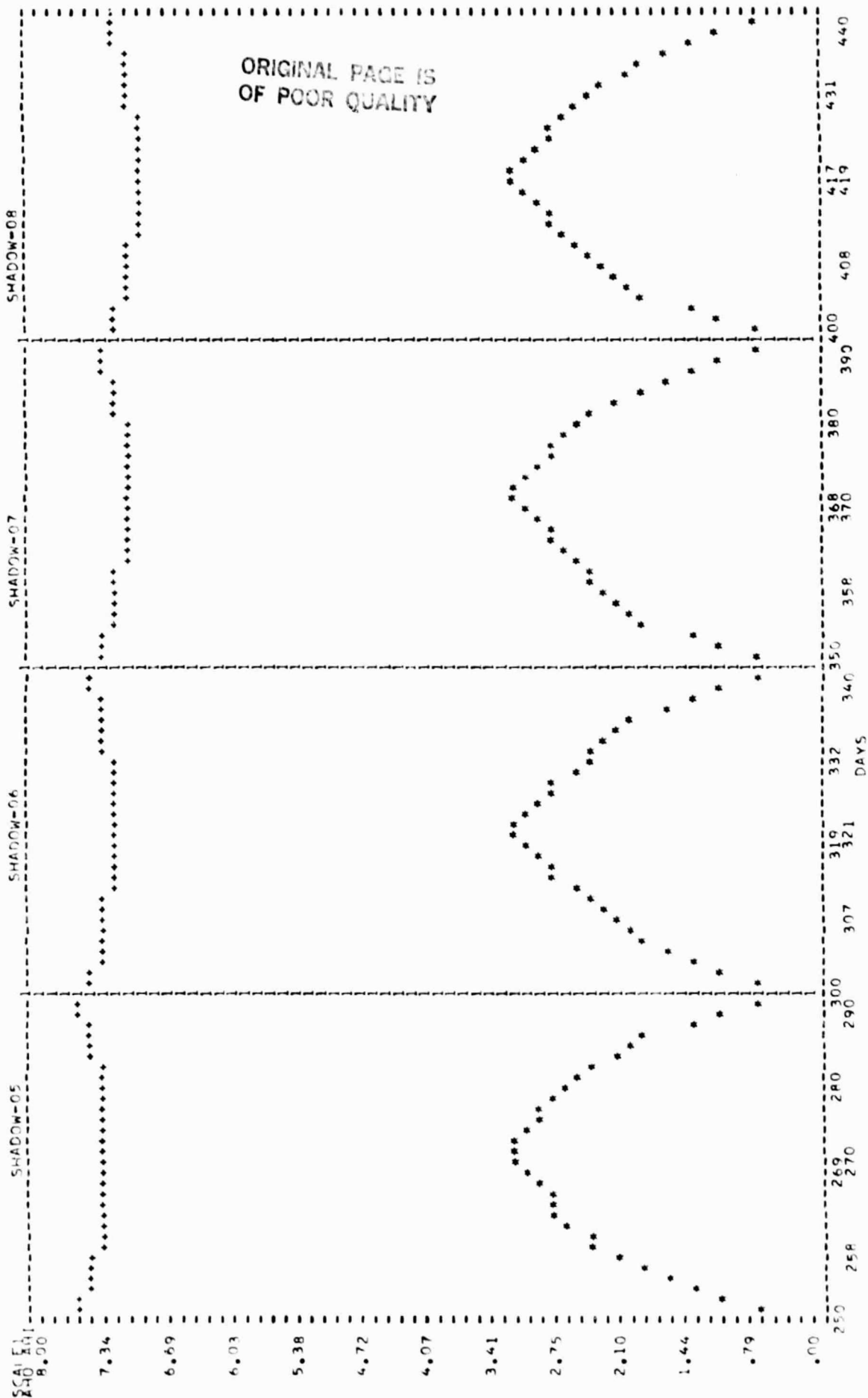
FIGURE 127

KEY
 * AHD
 + AHT-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52 WDEC/C 81-120A
 TEMPERATURE 15
 AMPERE RATE 06
 GENERAL ELECTRIC CELLS
 SERIAL 016 055 072 073 074
 GOES 5.1 F AND E

PACK = 227E



CHARGE CURRENT: .320 AMPERES CHARGE CURRENT: .315 AMPERES CHARGE CURRENT: .310 AMPERES CHARGE CURRENT: .305 AMPERES

KEY
 * AMO
 + AMI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52 WQEC/C 81-120A
 TEMPERATURE 15
 AMPERE RATE 06
 GENERAL ELECTRIC CELLS
 SERIAL 016 055 072 073 074
 GOES D, E AND F

PACW = 227E

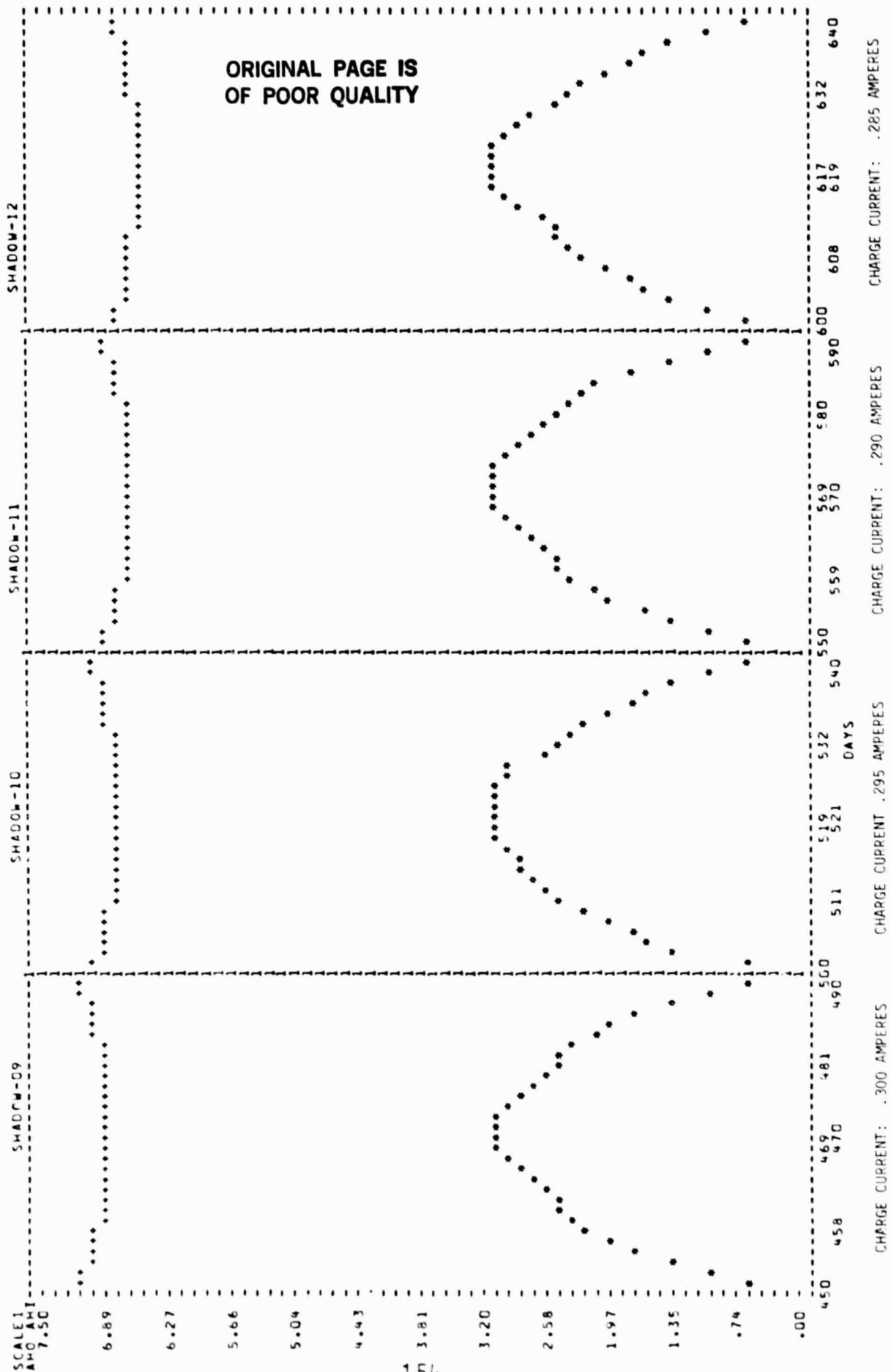


FIGURE 129

3. Pack 227F, 5-cells, accelerated test - high rate

a. Cell information: (Same as Pack 227D, Section V.D.1. except no cells from HAC)

b. Parameters: (41-day shadow period, 1 week sun period)

| | | | |
|------------------------|-----|----------------------------|------|
| Depth of Discharge (%) | 52 | Discharge Current (amps)** | 2.61 |
| Charge Control | CC | Temperature (°C) | 15 |
| Charge Current (amps)* | .26 | Float Current (amps) | .125 |

*-- Current was increased to .325 amps at the start of shadow 4. The current is decreased 5 ma for each succeeding shadow.

**-- Current is 5.30 amps the first and last 3 days of each shadow.

c. Capacity Check: *** (Discharge to .75 volts any cell following each 4th shadow period.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | <u>ah</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|-----------|
| Precycling (Figure 130) | 7.22 | 7.35 | 7.35 | 7.22 | 7.22 | |
| Shadow 4 (Figure 131) | .544 | 1.010 | .999 | .264 | .963 | 7.61 |
| Shadow 8 (Figure 132) | .912 | .955 | .950 | .594 | .898 | 7.40 |
| Shadow 12 (Figure 133) | .626 | .688 | .676 | .383 | .681 | 7.43 |

***-- Following the capacity check, a 60-ohm resistor is placed across the pack until the pack voltage is 5.00 volts.

d. Test Results during the Shadow Periods: (Figures 134 to 139)

(1) End of Mid-Shadow Discharge Voltages: The average voltages decreased from shadows 1 to 4 (1.208 to 1.173 volts), shadows 5 to 8 (1.187 to 1.166 volts), and shadows 9 to 12 (1.185 to 1.164 volts). The pack was capacity checked following shadows 4 and 8 which accounts for the increase in voltage for shadows 5 and 9. The largest decrease was between shadows 1 and 2 (19 mv), shadows 5 and 6 (8 mv), and shadows 9 and 10 (9 mv). There was a 3 mv difference between the high cell (5) and low cell (1) during the last shadow. The dip in voltages at the start and end of each shadow is due to the 5.30 amp discharge current.

(2) Capacity/Reconditioning Effects: There has been a 2.5 percent decrease in capacity from the capacity check performed following shadow 4 to the one following shadow 12. Voltage degradation is evident in that 62 percent of the total pack capacity was available above the 1.10 volt/cell average following shadow 4 and 49 percent following shadow 12. Also, there was a decrease in the capacity available to the 1.00 volt/cell average from 97 to 84 percent. The reconditioning effect, due to the daily discharges, is nonexistent the first shadow and the shadow following each capacity check, but is in evidence the other shadows with higher EOD voltages during the second half of each shadow.

(3) End of Mid-Shadow Charge Voltages: The voltages increased 9 mv from shadow 3 (1.432 volts) to 4 (1.441 volts) as the charge current was increased from .26 to .325 amperes. Voltage change from one shadow to another, due to the 5 ma decrease in charge current, is very slight as the average voltages decreased from 1.430 (shadow 6) to 1.426 volts (shadow 8) and were 1.433 volts for shadows 10 to 12. The cells have remained balanced with a maximum of 4 mv between the high and low cells except during shadow 9 when it was 6 mv. Enhancement of the EOD voltages or capacity is not evident due to the changing charge currents.

e. Performance during Sun Periods: Pack has completed 12, 1-week sun periods as it began test with a shadow period. The average voltage at the end of these periods is 1.423 volts with an increase of 4 mv those periods in which the pack is capacity checked.

KEY: HIGH CELL
LOW CELL
AVERAGE

PACK NUMBER IS 227F
RECORD AFTER SHADOW 241
CYCLE NUMBER IS 241
DISCHARGE RATE IS 2.61

WQEC/C 81-120A

AMPERE HOUR OUT

0.08 1.72 1.36 2.00 2.63 3.26 3.90 4.53 5.17 5.81 6.44 7.08 7.61
1.01 1.68 1.34 2.01 2.65 3.29 3.93 4.57 5.21 5.85 6.49 7.13 7.76

C A D A C I T Y C E L L V O L T A G E S C A L E
1.57 1.54 1.51 1.48 1.45 1.42 1.39 1.36 1.33 1.30 1.27 1.24 1.21 1.18 1.15 1.12 1.09 1.06 1.03 1.00 0.97 0.94 0.91 0.88 0.85 0.82 0.79 0.76 0.73 0.70 0.67 0.64 0.61 0.58 0.55 0.52 0.49 0.46 0.43 0.40 0.37 0.34 0.31 0.28 0.25 0.22 0.19 0.16 0.13 0.10 0.07 0.04 0.01 0.00

ORIGINAL PAGE IS
OF POOR QUALITY

1. 16. 30. 44. 59. 73. 87. 102. 116. 131. 145. 159. 171.
2. 15. 23. 37. 51. 66. 80. 95. 109. 123. 138. 152. 167.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 131

ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 227F
RECOND AFTER SHADOW 8
CYCLE NUMBER IS 441
DISCHARGE RATE IS 2.61

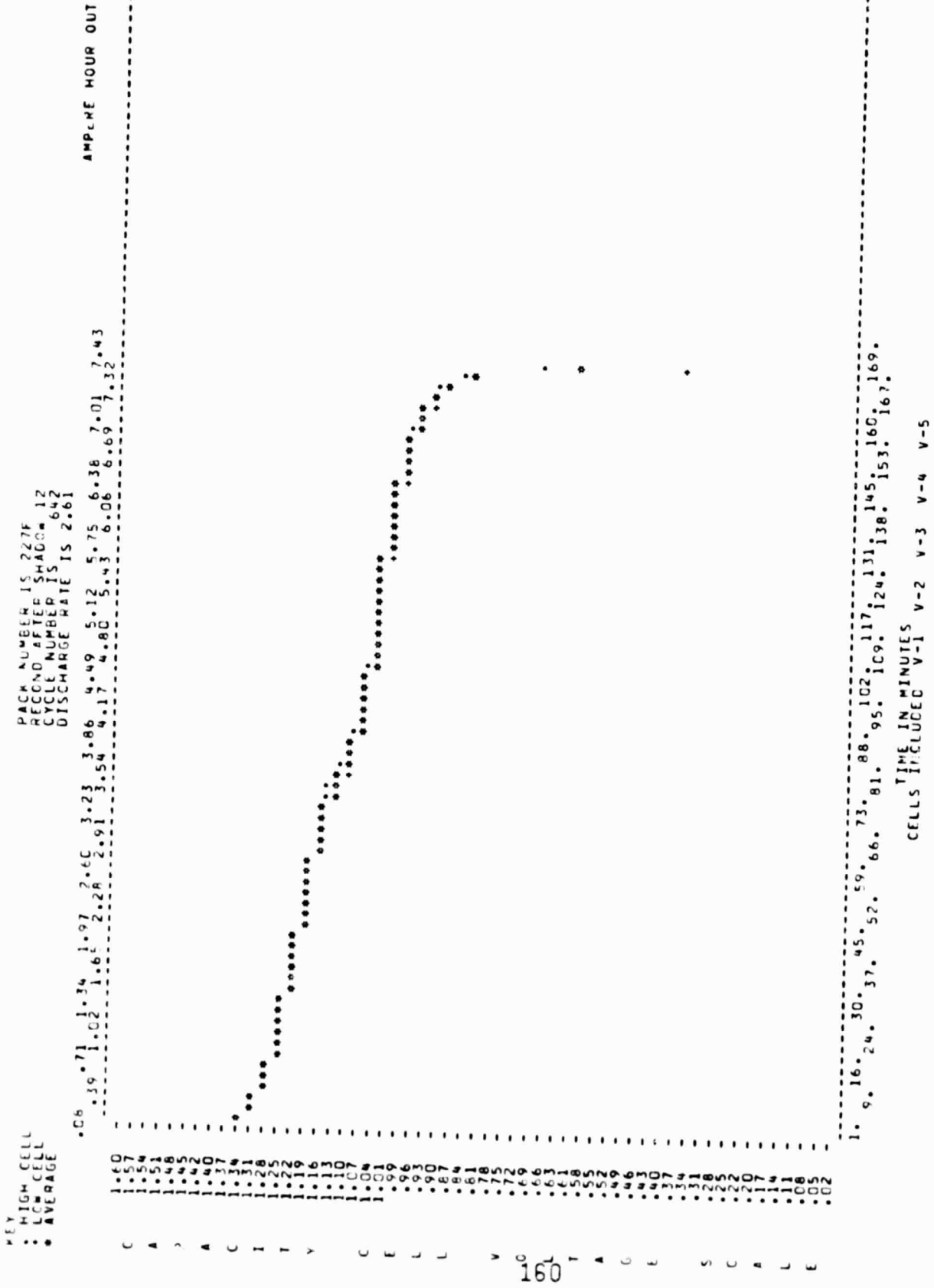
AMPERE HOUR OUT

10. 73 1.35 1.99 2.62 3.25 3.88 4.51 5.14 5.77 6.40 7.03 7.40
41 1.04 1.67 2.30 2.93 3.56 4.19 4.82 5.45 6.08 6.71 7.29

KFY HIGH CELL
LOW CELL
AVERAGE

1.07 1.03 1.05 1.08 1.15 1.18 1.20 1.22 1.25 1.26 1.29 1.31 1.33 1.35 1.37 1.39 1.41 1.43 1.45 1.47 1.49 1.51 1.53 1.55 1.57 1.59 1.61 1.63 1.65 1.67 1.69 1.71 1.73 1.75 1.77 1.79 1.81 1.83 1.85 1.87 1.89 1.91 1.93 1.95 1.97 1.99 2.01 2.03 2.05 2.07 2.09 2.11 2.13 2.15 2.17 2.19 2.21 2.23 2.25 2.27 2.29 2.31 2.33 2.35 2.37 2.39 2.41 2.43 2.45 2.47 2.49 2.51 2.53 2.55 2.57 2.59 2.61 2.63 2.65 2.67 2.69 2.71 2.73 2.75 2.77 2.79 2.81 2.83 2.85 2.87 2.89 2.91 2.93 2.95 2.97 2.99 3.01 3.03 3.05 3.07 3.09 3.11 3.13 3.15 3.17 3.19 3.21 3.23 3.25 3.27 3.29 3.31 3.33 3.35 3.37 3.39 3.41 3.43 3.45 3.47 3.49 3.51 3.53 3.55 3.57 3.59 3.61 3.63 3.65 3.67 3.69 3.71 3.73 3.75 3.77 3.79 3.81 3.83 3.85 3.87 3.89 3.91 3.93 3.95 3.97 3.99 4.01 4.03 4.05 4.07 4.09 4.11 4.13 4.15 4.17 4.19 4.21 4.23 4.25 4.27 4.29 4.31 4.33 4.35 4.37 4.39 4.41 4.43 4.45 4.47 4.49 4.51 4.53 4.55 4.57 4.59 4.61 4.63 4.65 4.67 4.69 4.71 4.73 4.75 4.77 4.79 4.81 4.83 4.85 4.87 4.89 4.91 4.93 4.95 4.97 4.99 5.01 5.03 5.05 5.07 5.09 5.11 5.13 5.15 5.17 5.19 5.21 5.23 5.25 5.27 5.29 5.31 5.33 5.35 5.37 5.39 5.41 5.43 5.45 5.47 5.49 5.51 5.53 5.55 5.57 5.59 5.61 5.63 5.65 5.67 5.69 5.71 5.73 5.75 5.77 5.79 5.81 5.83 5.85 5.87 5.89 5.91 5.93 5.95 5.97 5.99 6.01 6.03 6.05 6.07 6.09 6.11 6.13 6.15 6.17 6.19 6.21 6.23 6.25 6.27 6.29 6.31 6.33 6.35 6.37 6.39 6.41 6.43 6.45 6.47 6.49 6.51 6.53 6.55 6.57 6.59 6.61 6.63 6.65 6.67 6.69 6.71 6.73 6.75 6.77 6.79 6.81 6.83 6.85 6.87 6.89 6.91 6.93 6.95 6.97 6.99 7.01 7.03 7.05 7.07 7.09 7.11 7.13 7.15 7.17 7.19 7.21 7.23 7.25 7.27 7.29 7.31 7.33 7.35 7.37 7.39 7.41 7.43 7.45 7.47 7.49 7.51 7.53 7.55 7.57 7.59 7.61 7.63 7.65 7.67 7.69 7.71 7.73 7.75 7.77 7.79 7.81 7.83 7.85 7.87 7.89 7.91 7.93 7.95 7.97 7.99 8.01 8.03 8.05 8.07 8.09 8.11 8.13 8.15 8.17 8.19 8.21 8.23 8.25 8.27 8.29 8.31 8.33 8.35 8.37 8.39 8.41 8.43 8.45 8.47 8.49 8.51 8.53 8.55 8.57 8.59 8.61 8.63 8.65 8.67 8.69 8.71 8.73 8.75 8.77 8.79 8.81 8.83 8.85 8.87 8.89 8.91 8.93 8.95 8.97 8.99 9.01 9.03 9.05 9.07 9.09 9.11 9.13 9.15 9.17 9.19 9.21 9.23 9.25 9.27 9.29 9.31 9.33 9.35 9.37 9.39 9.41 9.43 9.45 9.47 9.49 9.51 9.53 9.55 9.57 9.59 9.61 9.63 9.65 9.67 9.69 9.71 9.73 9.75 9.77 9.79 9.81 9.83 9.85 9.87 9.89 9.91 9.93 9.95 9.97 9.99 10.01 10.03 10.05 10.07 10.09 10.11 10.13 10.15 10.17 10.19 10.21 10.23 10.25 10.27 10.29 10.31 10.33 10.35 10.37 10.39 10.41 10.43 10.45 10.47 10.49 10.51 10.53 10.55 10.57 10.59 10.61 10.63 10.65 10.67 10.69 10.71 10.73 10.75 10.77 10.79 10.81 10.83 10.85 10.87 10.89 10.91 10.93 10.95 10.97 10.99 11.01 11.03 11.05 11.07 11.09 11.11 11.13 11.15 11.17 11.19 11.21 11.23 11.25 11.27 11.29 11.31 11.33 11.35 11.37 11.39 11.41 11.43 11.45 11.47 11.49 11.51 11.53 11.55 11.57 11.59 11.61 11.63 11.65 11.67 11.69 11.71 11.73 11.75 11.77 11.79 11.81 11.83 11.85 11.87 11.89 11.91 11.93 11.95 11.97 11.99 12.01 12.03 12.05 12.07 12.09 12.11 12.13 12.15 12.17 12.19 12.21 12.23 12.25 12.27 12.29 12.31 12.33 12.35 12.37 12.39 12.41 12.43 12.45 12.47 12.49 12.51 12.53 12.55 12.57 12.59 12.61 12.63 12.65 12.67 12.69 12.71 12.73 12.75 12.77 12.79 12.81 12.83 12.85 12.87 12.89 12.91 12.93 12.95 12.97 12.99 13.01 13.03 13.05 13.07 13.09 13.11 13.13 13.15 13.17 13.19 13.21 13.23 13.25 13.27 13.29 13.31 13.33 13.35 13.37 13.39 13.41 13.43 13.45 13.47 13.49 13.51 13.53 13.55 13.57 13.59 13.61 13.63 13.65 13.67 13.69 13.71 13.73 13.75 13.77 13.79 13.81 13.83 13.85 13.87 13.89 13.91 13.93 13.95 13.97 13.99 14.01 14.03 14.05 14.07 14.09 14.11 14.13 14.15 14.17 14.19 14.21 14.23 14.25 14.27 14.29 14.31 14.33 14.35 14.37 14.39 14.41 14.43 14.45 14.47 14.49 14.51 14.53 14.55 14.57 14.59 14.61 14.63 14.65 14.67 14.69 14.71 14.73 14.75 14.77 14.79 14.81 14.83 14.85 14.87 14.89 14.91 14.93 14.95 14.97 14.99 15.01 15.03 15.05 15.07 15.09 15.11 15.13 15.15 15.17 15.19 15.21 15.23 15.25 15.27 15.29 15.31 15.33 15.35 15.37 15.39 15.41 15.43 15.45 15.47 15.49 15.51 15.53 15.55 15.57 15.59 15.61 15.63 15.65 15.67 15.69 15.71 15.73 15.75 15.77 15.79 15.81 15.83 15.85 15.87 15.89 15.91 15.93 15.95 15.97 15.99 16.01 16.03 16.05 16.07 16.09 16.11 16.13 16.15 16.17 16.19 16.21 16.23 16.25 16.27 16.29 16.31 16.33 16.35 16.37 16.39 16.41 16.43 16.45 16.47 16.49 16.51 16.53 16.55 16.57 16.59 16.61 16.63 16.65 16.67 16.69 16.71 16.73 16.75 16.77 16.79 16.81 16.83 16.85 16.87 16.89 16.91 16.93 16.95 16.97 16.99 17.01 17.03 17.05 17.07 17.09 17.11 17.13 17.15 17.17 17.19 17.21 17.23 17.25 17.27 17.29 17.31 17.33 17.35 17.37 17.39 17.41 17.43 17.45 17.47 17.49 17.51 17.53 17.55 17.57 17.59 17.61 17.63 17.65 17.67 17.69 17.71 17.73 17.75 17.77 17.79 17.81 17.83 17.85 17.87 17.89 17.91 17.93 17.95 17.97 17.99 18.01 18.03 18.05 18.07 18.09 18.11 18.13 18.15 18.17 18.19 18.21 18.23 18.25 18.27 18.29 18.31 18.33 18.35 18.37 18.39 18.41 18.43 18.45 18.47 18.49 18.51 18.53 18.55 18.57 18.59 18.61 18.63 18.65 18.67 18.69 18.71 18.73 18.75 18.77 18.79 18.81 18.83 18.85 18.87 18.89 18.91 18.93 18.95 18.97 18.99 19.01 19.03 19.05 19.07 19.09 19.11 19.13 19.15 19.17 19.19 19.21 19.23 19.25 19.27 19.29 19.31 19.33 19.35 19.37 19.39 19.41 19.43 19.45 19.47 19.49 19.51 19.53 19.55 19.57 19.59 19.61 19.63 19.65 19.67 19.69 19.71 19.73 19.75 19.77 19.79 19.81 19.83 19.85 19.87 19.89 19.91 19.93 19.95 19.97 19.99 20.01 20.03 20.05 20.07 20.09 20.11 20.13 20.15 20.17 20.19 20.21 20.23 20.25 20.27 20.29 20.31 20.33 20.35 20.37 20.39 20.41 20.43 20.45 20.47 20.49 20.51 20.53 20.55 20.57 20.59 20.61 20.63 20.65 20.67 20.69 20.71 20.73 20.75 20.77 20.79 20.81 20.83 20.85 20.87 20.89 20.91 20.93 20.95 20.97 20.99 21.01 21.03 21.05 21.07 21.09 21.11 21.13 21.15 21.17 21.19 21.21 21.23 21.25 21.27 21.29 21.31 21.33 21.35 21.37 21.39 21.41 21.43 21.45 21.47 21.49 21.51 21.53 21.55 21.57 21.59 21.61 21.63 21.65 21.67 21.69 21.71 21.73 21.75 21.77 21.79 21.81 21.83 21.85 21.87 21.89 21.91 21.93 21.95 21.97 21.99 22.01 22.03 22.05 22.07 22.09 22.11 22.13 22.15 22.17 22.19 22.21 22.23 22.25 22.27 22.29 22.31 22.33 22.35 22.37 22.39 22.41 22.43 22.45 22.47 22.49 22.51 22.53 22.55 22.57 22.59 22.61 22.63 22.65 22.67 22.69 22.71 22.73 22.75 22.77 22.79 22.81 22.83 22.85 22.87 22.89 22.91 22.93 22.95 22.97 22.99 23.01 23.03 23.05 23.07 23.09 23.11 23.13 23.15 23.17 23.19 23.21 23.23 23.25 23.27 23.29 23.31 23.33 23.35 23.37 23.39 23.41 23.43 23.45 23.47 23.49 23.51 23.53 23.55 23.57 23.59 23.61 23.63 23.65 23.67 23.69 23.71 23.73 23.75 23.77 23.79 23.81 23.83 23.85 23.87 23.89 23.91 23.93 23.95 23.97 23.99 24.01 24.03 24.05 24.07 24.09 24.11 24.13 24.15 24.17 24.19 24.21 24.23 24.25 24.27 24.29 24.31 24.33 24.35 24.37 24.39 24.41 24.43 24.45 24.47 24.49 24.51 24.53 24.55 24.57 24.59 24.61 24.63 24.65 24.67 24.69 24.71 24.73 24.75 24.77 24.79 24.81 24.83 24.85 24.87 24.89 24.91 24.93 24.95 24.97 24.99 25.01 25.03 25.05 25.07 25.09 25.11 25.13 25.15 25.17 25.19 25.21 25.23 25.25 25.27 25.29 25.31 25.33 25.35 25.37 25.39 25.41 25.43 25.45 25.47 25.49 25.51 25.53 25.55 25.57 25.59 25.61 25.63 25.65 25.67 25.69 25.71 25.73 25.75 25.77 25.79 25.81 25.83 25.85 25.87 25.89 25.91 25.93 25.95 25.97 25.99 26.01 26.03 26.05 26.07 26.09 26.11 26.13 26.15 26.17 26.19 26.21 26.23 26.25 26.27 26.29 26.31 26.33 26.35 26.37 26.39 26.41 26.43 26.45 26.47 26.49 26.51 26.53 26.55 26.57 26.59 26.61 26.63 26.65 26.67 26.69 26.71 26.73 26.75 26.77 26.79 26.81 26.83 26.85 26.87 26.89 26.91 26.93 26.95 26.97 26.99 27.01 27.03 27.05 27.07 27.09 27.11 27.13 27.15 27.17 27.19 27.21 27.23 27.25 27.27 27.29 27.31 27.33 27.35 27.37 27.39 27.41 27.43 27.45 27.47 27.49 27.51 27.53 27.55 27.57 27.59 27.61 27.63 27.65 27.67 27.69 27.71 27.73 27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89 27.91 27.93 27.95 27.97 27.99 28.01 28.03 28.05 28.07 28.09 28.11 28.13 28.15 28.17 28.19 28.21 28.23 28.25 28.27 28.29 28.31 28.33 28.35 28.37 28.39 28.41 28.43 28.45 28.47 28.49 28.51 28.53 28.55 28.57 28.59 28.61 28.63 28.65 28.67 28.69 28.71 28.73 28.75 28.77 28.79 28.81 28.83 28.85 28.87 28.89 28.91 28.93 28.95 28.97 28.99 29.01 29.03 29.05 29.07 29.09 29.11 29.13 29.15 29.17 29.19 29.21 29.23 29.25 29.27 29.29 29.31 29.33 29.35 29.37 29.39 29.41 29.43 29.45 29.47 29.49 29.51 29.53 29.55 29.57 29.59 29.61 29.63 29.65 29.67 29.69 29.71 29.73 29.75 29.77 29.79 29.81 29.83 29.85 29.87 29.89 29.91 29.93 29.95 29.97 29.99 30.01 30.03 30.05 30.07 30.09 30.11 30.13 30.15 30.17 30.19 30.21 30.23 30.25 30.27 30.29 30.31 30.33 30.35 30.37 30.39 30.41 30.43 30.45 30.47 30.49 30.51 30.53 30.55 30.57 30.59 30.61 30.63 30.65 30.67 30.69 30.71 30.73 30.75 30.77 30.79 30.81 30.83 30.85 30.87 30.89 30.91 30.93 30.95 30.97 30.99 31.01 31.03 31.05 31.07 31.09 31.11 31.13 31.15 31.17 31.19 31.21 31.23 31.25 31.27 31.29 31.31 31.33 31.35 31.37 31.39 31.41 31.43 31.45 31.47 31.49 31.51 31.53 31.55 31.57 31.59 31.61 31.63 31.65 31.67 31.69 31.71 31.73 31.75 31.77 31.79 31.81 31.83 31.85 31.87 31.89 31.91 31.93 31.95 31.97 31.99 32.01 32.03 32.05 32.07 32.09 32.11 32.13 32.15 32.17 32.19 32.21 32.23 32.25 32.27 32.29 32.31 32.33 32.35 32.37 32.39 32.41 32.43 32.45 32.47 32.49 32.51 32.53 32.55 32.57 32.59 32.61 32.63 32.65 32.67 32.69 32.71 32.73 32.75 32.77 32.79 32.81 32.83 32.85 32.87 32.89 32.91 32.93 32.95 32.97 32.99 33.01 33.03 33.05 33.07 33.09 33.11 33.13 33.15 33.17 33.19 33.21 33.23 33.25 33.27 33.29 33.31 33.33 33.35 33.37 33.39 33.41 33.43 33.45 33.47 33.49 33.51 33.53 33.55 33.57 33.59 33.61 33.63 33.65 33.67 33.69 33.71 33.73 33.75 33.77 33.79 33.81 33.83 33.85 33.87 33.89 33.91 33.93 33.95 33.97 33.99 34.01 34.03 34.05 34.07 34.09 34.11 34.13 34.15 34.17 34.19 34.21 34.23 34.25 34.27 34.29 34.31 34.33 34.35 34.37 34.39 34.41 34.43 34.45 34.47 34.49 34.51 34.53 34.55 34.57 34.59 34.61 34.63 34.65 34.67 34.69 34.71 34.73 34.75 34.77 34.79 34.81 34.83 34.85 34.87 34.89 34.91 34.93 34.95 34.97 34.99 35.01 35.03 35.05 35.07 35.09 35.11 35.13 35.15 35.17 35.19 35.21 35.23 35.25 35.27 35.29 35.31 35.33 35.35 35.37 35.39 35.41 35.43 35.45 35.47 35.49 35.51 35.53 35.55 35.57 35.59 35.61 35.63 35.65 35.67 35.69 35.71 35.73 35.75 35.77 35.79 35.81 35.83 35.85 35.87 35.89 35.91 35.93 35.95 35.97 35.99 36.01 36.03 36.05 36.07 36.09 36.11 36.13 36.15 36.17 36.19 36.21 36.23 36.25 36.27 36.29 36.31 36.33 36.35 36.37 36.39 36.41 36.43 36.45 36.47 36.49 36.51 36.53 36.55 36.57 36.59 36.61 36.63 36.65 36.67 36.69 36.71 36.73 36.75 36.77 36.79 36.81 36.83 36.85 36.87 36.89 36.91 36.93 36.95 36.97 36.99 37.01 37.03 37.05 37.07 37.09 37.11 37.13 37.15 37.17 37.19 37.21 37.23 37.25 37.27 37.29 37.31 37.33 37.35 37.37 37.39 37.41 37.43 37.45 37.47 37.49 37.51 37.53 37.55 37.57 37.59 37.61 37.63 37.65 37.67 37.69 37.71 37.73 37.75 37.77 37.79 37.81 37.83 37.85 37.87 37.89 37.91 37.93 37.95 37.97 37.99 38.01 38.03 38.05 38.07 38.09 38.11 38.13 38.15 38.17 38.19 38.21 38.23 38.25 38.27 38.29 38.31 38.33 38.35 38.37 38.39 38.41 38.43 38.45 38.47 38.49 38.51 38.53 38.55 38.57 38.59 38.61 38.63 38.65 38.67 38.69 38.71 38.73 38.75 38.77 38.79 38.81 38.83 38.85 38.87 38.89 38.91 38.93 38.95 38.97 38.99 39.01 39.03 39.05 39.07 39.09 39.11 39.13 39.15 39.17 39.19 39.21 39.23 39.25 39.27 39.29 39.31 39.33 39.35 39.37 39.39 39.41 39.43 39.45 39.47 39.49 39.51 39.53 39.55 39.57 39.59 39.61 39.63 39.65 39.67 39.69 39.71 39.73 39.75 39.77 39.79 39.81 39.83 39.85 39.87 39.89 39.91 39.93 39.95 39.97 39.99 40.01 40.03 40.05 40.07 40.09 40.11 40.13 40.15 40.17 40.19 40.21 40.23 40.25 40.27 40.29 40.31 40.33 40.35 40.37 40.39 40.41 40.43 40.45 40.47 40.49 40.51 40.53 40.55 40.57 40.59 40.61 40.63 40.65 40.67 40.69 40.71 40.73 40.75 40.77 40.79 40.81 40.83 40.85 40.87 40.89 40.91 40.93 40.95 40.97 40.99 41.01 41.03 41.05 41.07 41.09 41.11 41.13 41.15 41.17 41.19 41.21 41.23 41.25 41.27 41.29 41.31 41.33 41.35 41.37 41.39 41.41 41.43 41.45 41.47 41.49 41.51 41.53 41.55 41.57 41.59 41.61 41.63 41.65 41.67 41.69 41.71 41.73 41.75 41.77 41.79 41.81 41.83 41.85 41.87 41.89 41.91 41.93 41.95 41.97 41.99 42.01 42.03 42.05 42.07 42.09 42.11 42.13 42.15 42.17 42.19 42.21 42.23 42.25 42.27 42.29 42.31 42.33 42.35 42

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OF POOR QUALITY



KEY
 • HIGH END DISCHARGE VOLTAGE
 • AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 • HIGH EOC
 • AVE EOC
 • LOW EOC

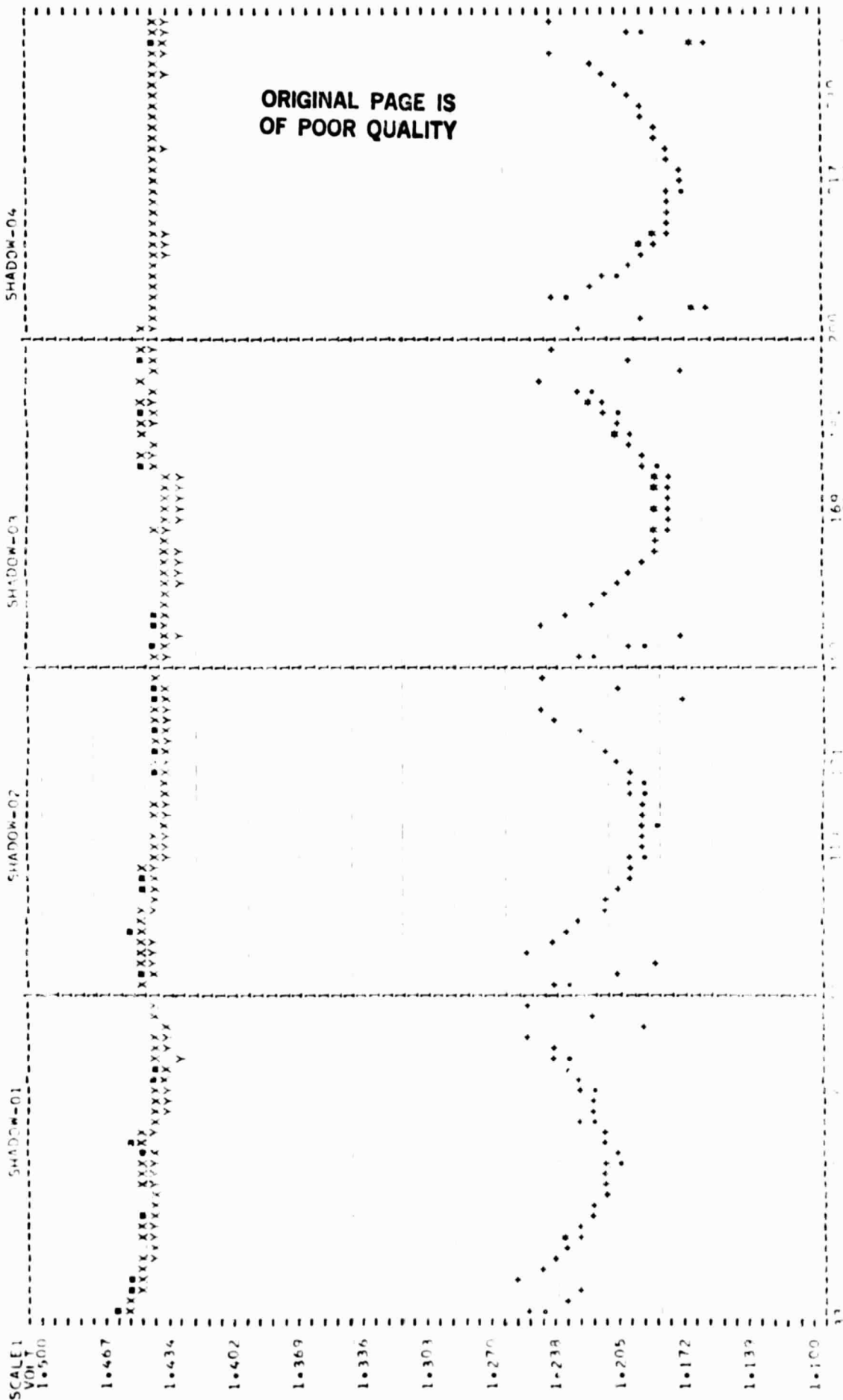
SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52
 TEMPERATURE 15
 AMPERE RATE 06
 GENERAL ELECTRIC CELLS

SERIAL 076 077 078 079 080

GOES D+E AND F

PACK = 227F



KEY
 * HIGH END DISCHARGE VOLTAGE
 + AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 X HIGH SOC
 Y LOW SOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52 WQEC/C 81-120A
 TEMPERATURE 15
 AMPERE RATE 00
 GENERAL ELECTRIC CELLS

SERIAL 076 077 078 079 080
 GOES D+E AND F

PACK = 227F

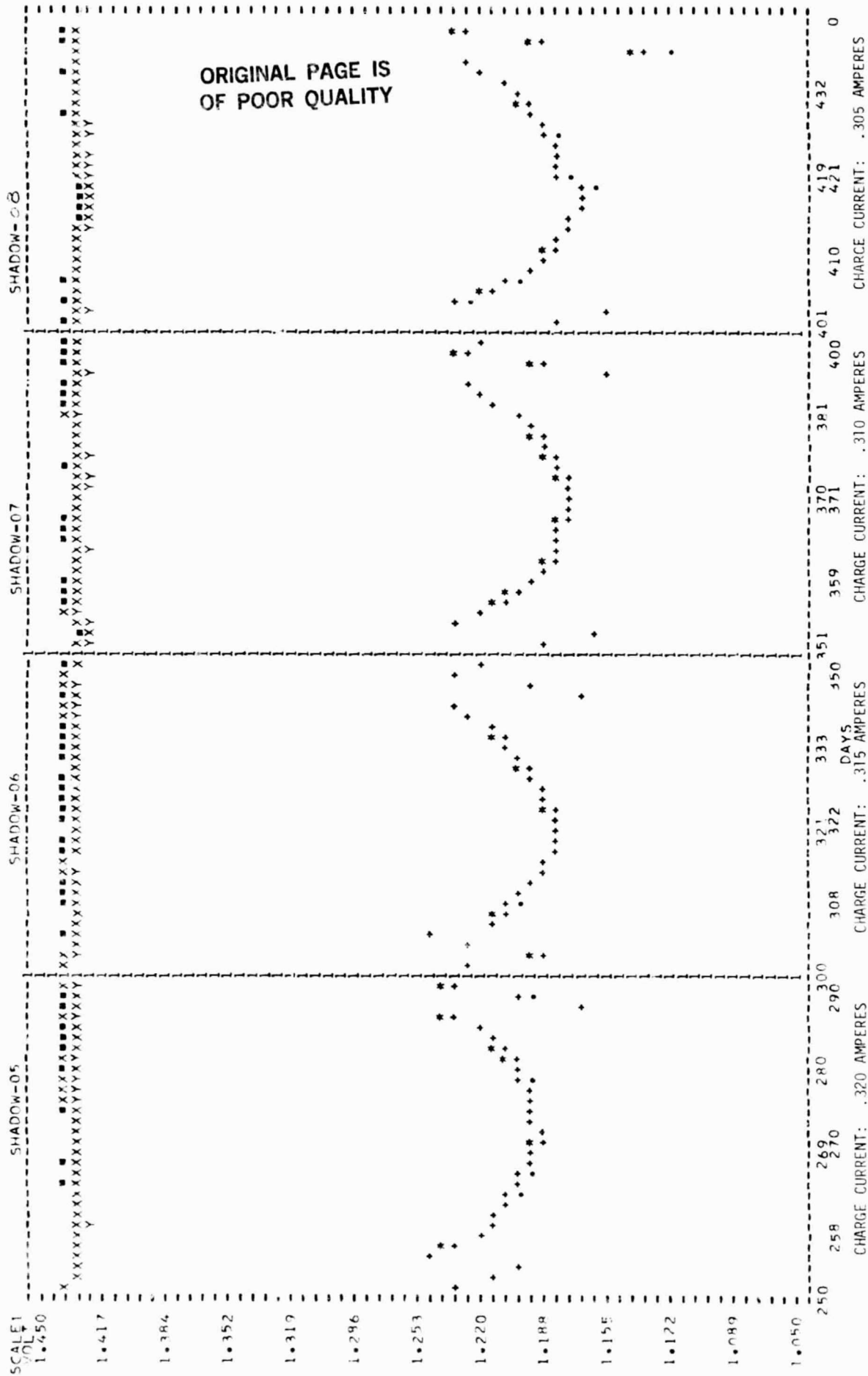


FIGURE 135

WQEC/C 81-120A

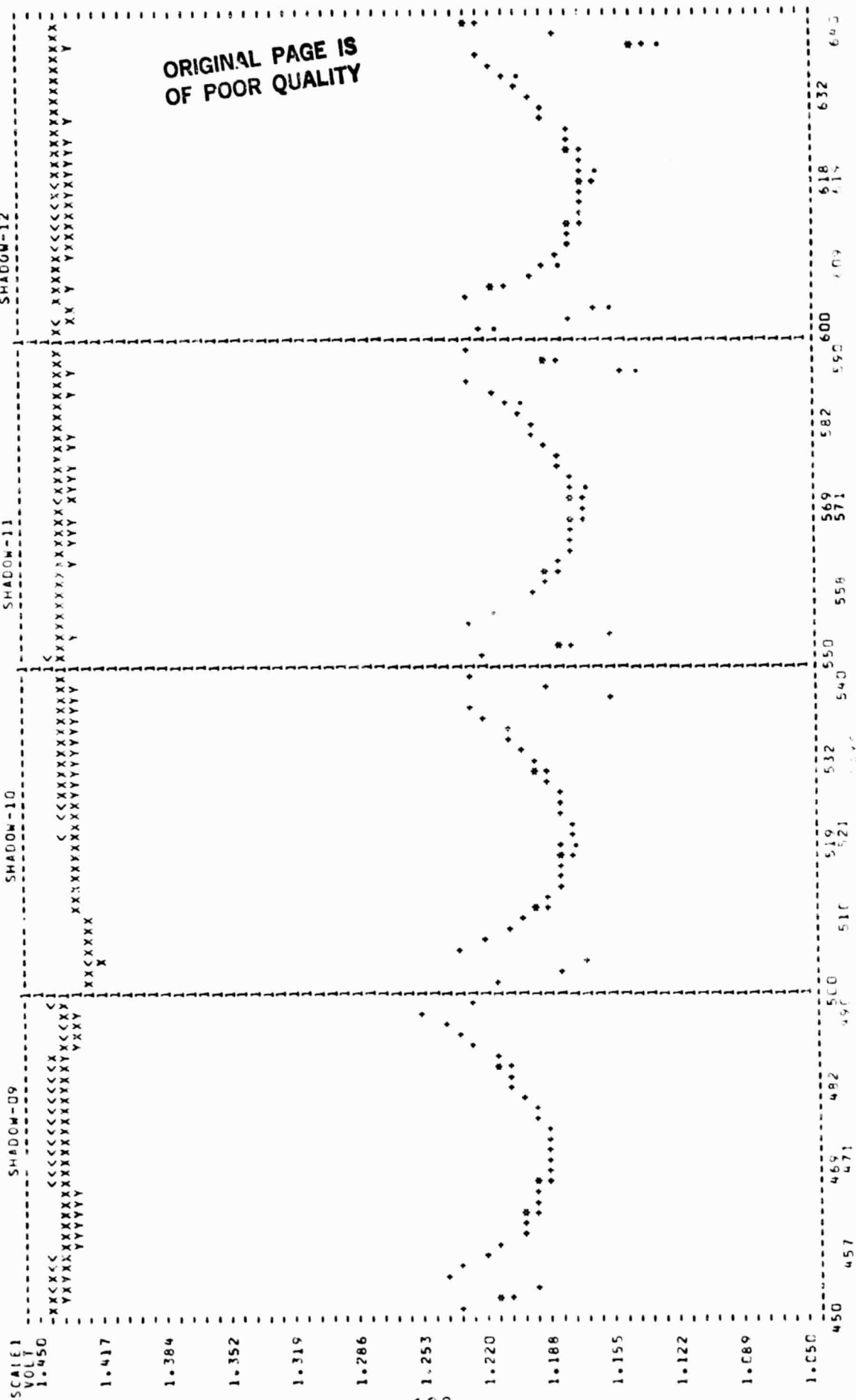
DEPTH DISCHARGE 52
TEMPERATURE 15
AMPERE RATE 06
GENERAL ELECTRIC CELLS

SERIAL 076 077 078 079 080
GOES D, F AND F

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
* HIGH END DISCHARGE VOLTAGE
+ AVE END DISCHARGE VOLTAGE
• LOW END DISCHARGE VOLTAGE
x HIGH EOC
x AVE EOC
y LOW EOC

PACK = 227F



KEY
 * AHO - TOTAL
 + AHI - TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

WQEC/C 81-120A
 DEPTH DISCHARGE 52
 TEMPERATURE 15
 AMPERE RATE 06
 GENERAL ELECTRIC CELLS
 SERIAL 076 077 078 079 080
 COES D.F. AND F

PAGE = 227F

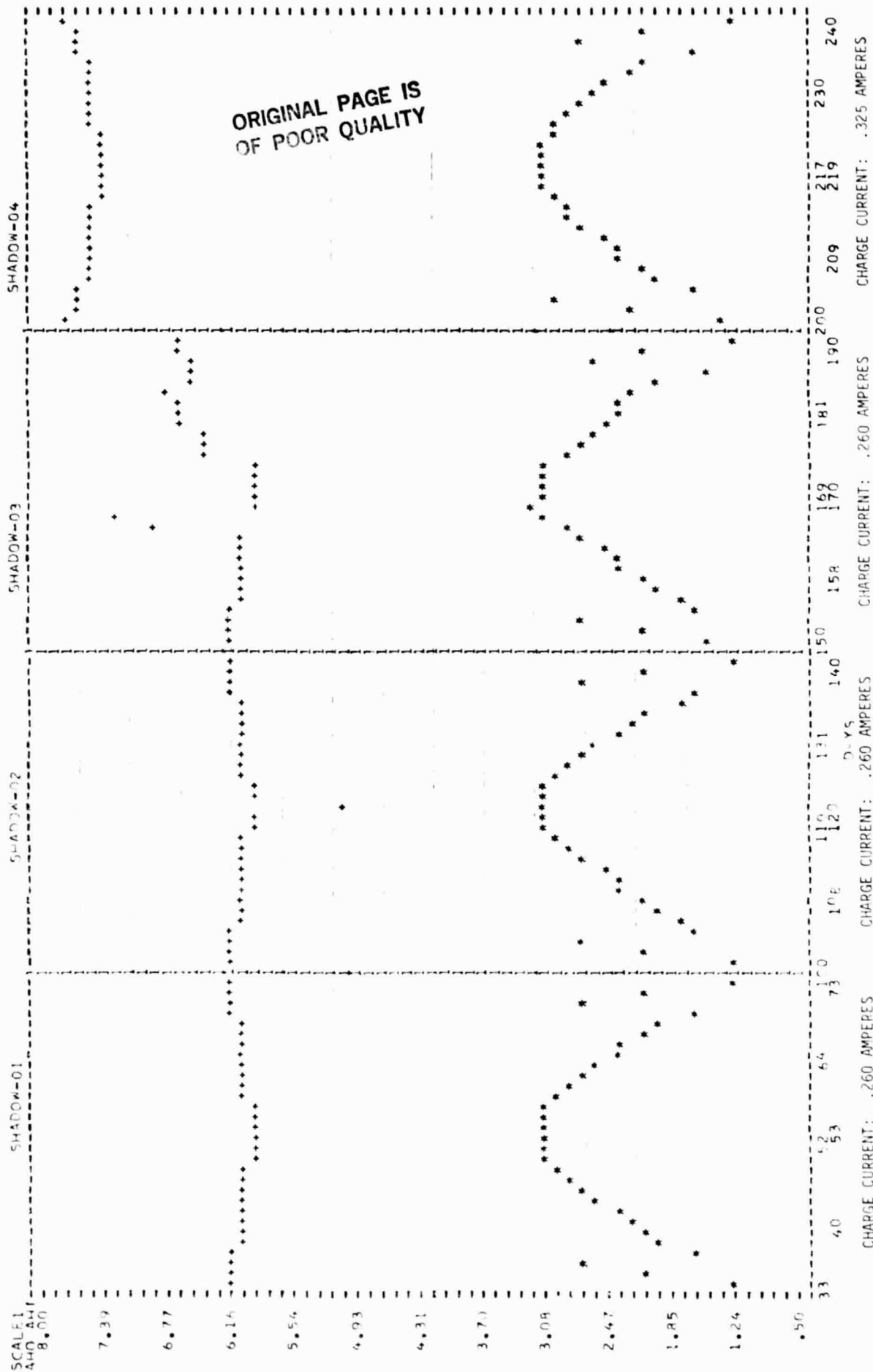


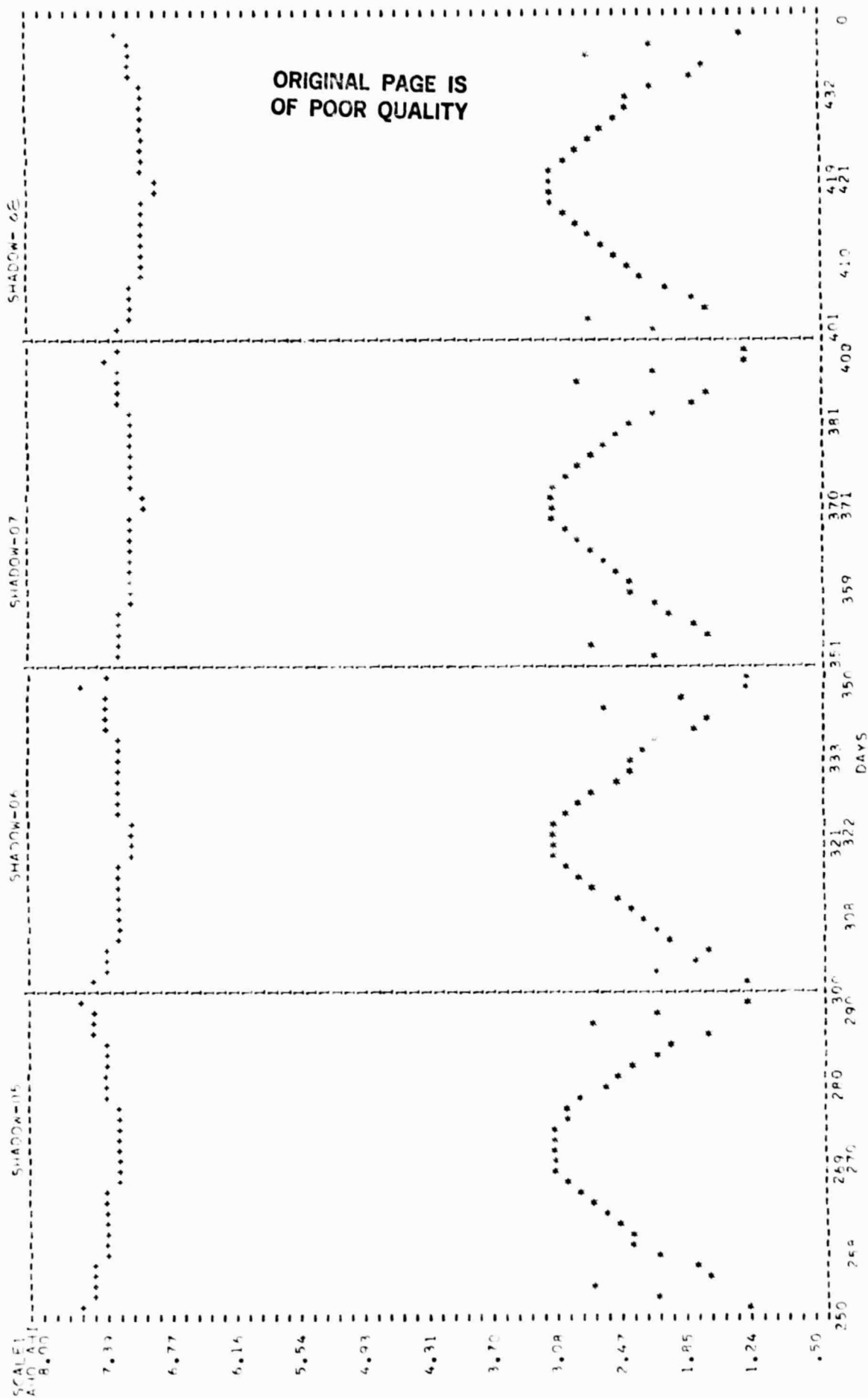
FIGURE 137

KEY
 * AUTO
 • AIT-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 52 W0EC/C 81-120A
 TEMPERATURE 15
 AMPERE RATE 0.1
 GENERAL ELECTRIC CELLS
 SERIAL 074, 073, 072, 079, 080
 GOES 3, F AND 7

PACV = 227F



CHARGE CURRENT: 320 AMPERES CHARGE CURRENT: 315 AMPERES CHARGE CURRENT: 310 AMPERES CHARGE CURRENT: 305 AMPERES

DEPTH DISCHARGE 52 WQEC/C 81-120A
 TEMPERATURE 15
 AMPERE RATE 06
 GENERAL ELECTRIC CELLS
 SERIAL 076 077 078 079 080
 GOES D, E AND F

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 227F

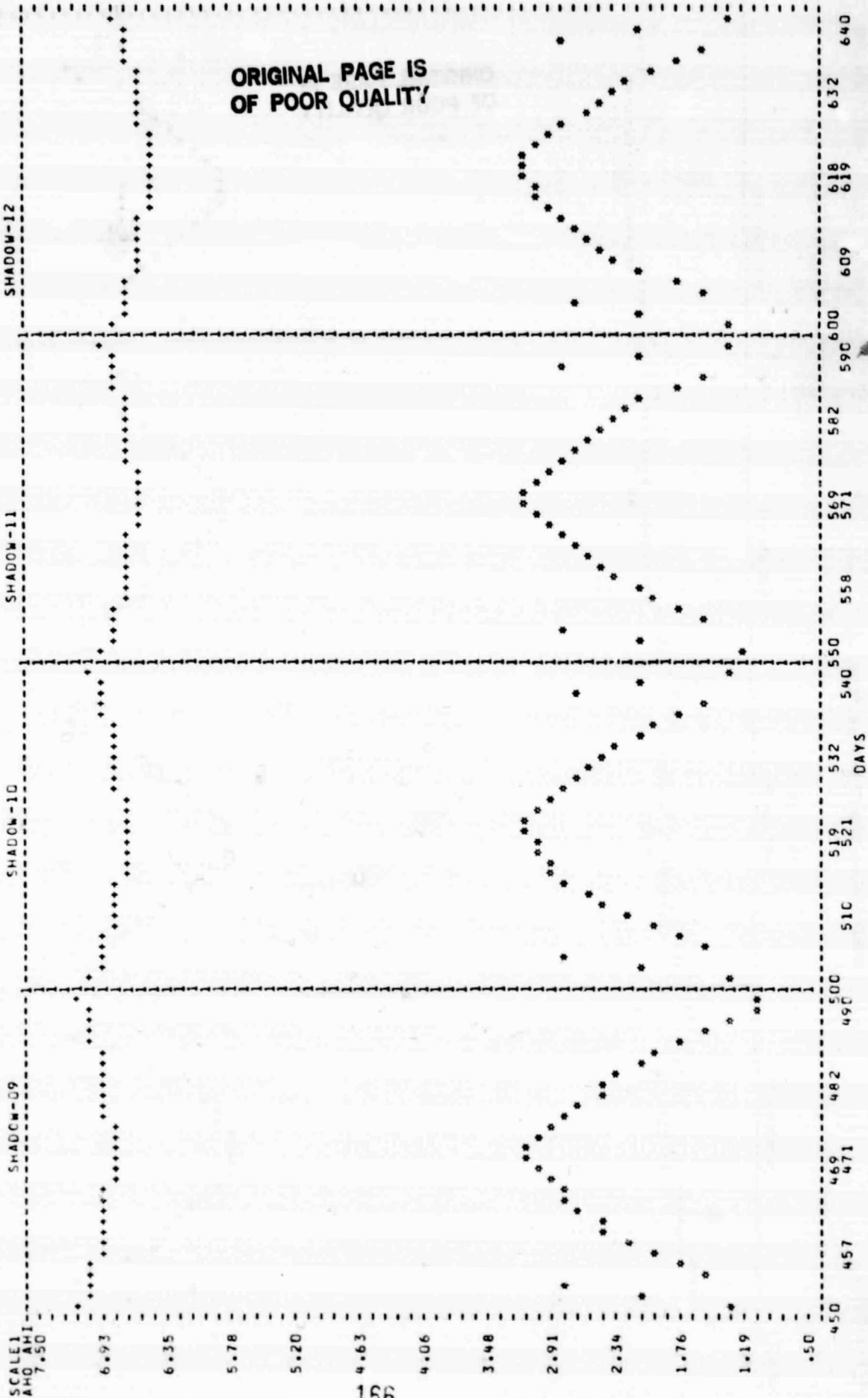


FIGURE 139

E. EP 12.0 ah

1. Pack 221A, 5-cells

a. Cell information:

(1) The cells were purchased by NASA, GSFC under contract number NAS 5-16530. The cells contained auxiliary electrodes and cells 1, 3 and 5 had pressure gauges. The cells were identified by the manufacturer as RSN-12B type cells. Acceptance test results are contained in the NAD Crane Report QEEL/C 71-366 of 8 December 1971. The results of the first nine eclipse seasons were reported in Crane Report WQEC/C 77-134 of 9 June 1977.

(2) A total of 3 uncycled cells each were sent to GSFC and EP for analysis.

b. Parameters:

| | | | |
|--------------------------|-------|----------------------|-------|
| Depth of Discharge (%) | 60 | Temperature (°C) | 20 |
| Charge Control | VL | Float Voltage (v/c) | 1.420 |
| Charge Current (amps) | 1.20 | Auxiliary Electrode: | |
| Discharge Current (amps) | 6.00 | Resistance (ohms) | 20 |
| Voltage Limit (v/c) | 1.420 | | |

**-- Placed on .20 ampere constant current charge during its first sun period due to the pack overcharging.

c. Capacity Checks: (Discharge to .50 volts any cell)

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell**
5 | ah
out |
|------------------------|-----------|-----------|-----------|-----------|-------------|-----------|
| Precycling | .842 | .995 | .954 | .996 | .500 | 15.20 |
| Shadow 1 | 1.048 | .995 | .464 | .927 | .539 | 16.57 |
| Shadow 2 | 1.005 | .969 | .517 | .946 | .377 | 16.36 |
| Shadow 3 | 1.018 | .989 | .480 | .939 | .642 | 15.52 |
| Shadow 4 | .964 | .931 | .444 | .864 | .631 | 16.70 |
| Shadow 5 | .955 | .944 | .553 | .847 | .460 | 15.84 |
| Shadow 6 | 1.048 | 1.063 | 1.056 | .957 | .481 | 12.32 |
| Shadow 7 | 1.053 | 1.054 | 1.045 | .963 | .498 | 11.0 |
| Shadow 8 | 1.044 | 1.046 | 1.027 | .984 | .498 | 9.81 |
| Shadow 9 | 1.039 | 1.033 | 1.027 | .984 | .487 | 10.06 |
| Shadow 10 (Figure 140) | 1.052 | 1.033 | 1.027 | .982 | .453 | 9.23 |
| Shadow 11 (Figure 141) | 1.153 | 1.159 | 1.166 | .936 | .435 | 7.29 |
| Shadow 12 (Figure 142) | 1.014 | .969 | .015 | .892 | 4.72 | 11.89 |
| Shadow 13 (Figure 143) | .977 | .424 | .024 | .827 | 3.88 | 12.82 |
| Shadow 14 (Figure 144) | 15.34 | 11.93 | 11.56 | 13.72 | 4.82 | |
| Post | | | | | | |
| Cycling (Figure 145) | 11.54 | 10.68 | 11.24 | 11.24 | 7.34 | |

**--Cell 5 failed on day 2153 of shadow 11, low discharge voltage; but allowed to continue cycling.

d. Test results during the Shadow Periods: (Figures 146 to 151)

(1) End of Discharge Voltages: There is a sharp decline in the low EOD voltages following shadow 5, due to cell 5. This cell failed on day 2153, during shadow 11; but it was allowed to continue cycling and began to reverse on day 2155. The reconditioning effect, due to the capacity checks, is present during the shadow periods except for the low EOD voltages (after shadow 5) because of cell 5. A malfunction in the control unit, prior to shadow 6, permitted the pack to be overcharged to the extent that the cell cases were slightly swollen. Also, cell 1 and 2 were found to have leaks around their negative terminals.

(2) End of Charge Voltages: The cells were unbalanced during the shadow periods, at the end of charge. This condition led to the pack's temperature increasing during the third shadow period in which the ampere-hour input and end of charge current increased while the pack voltage decreased. Also, this divergence became acute during shadow 11, in which cell 5 failed, which resulted in maximum ampere-hour input.

(3) Ampere-Hour Input: The amount returned to the pack increases as the cell voltages become more unbalanced and also as the temperature of the pack increases due to the increasing amount of input. The difference in the ampere-hour graph for shadow 6 may be due to the cells being overcharged during the preceding sun period. The varying degrees of input, following shadow 10, is due to the behavior of cell 5.

(4) Pressures at End of Charge: Pressures remained in a vacuum during the first 2 shadows; but increased to 100 psia during the middle of shadow 3, when the pack's temperature increased. Following shadow 3, the pressures steadily declined, as observed in the middle portion of the shadow periods, in which cell 3 indicated a pressure (40 PSIA) during shadow 9 and 23 PSIA during shadow 14.

(5) The pack was discontinued in the middle of shadow 14 in which each cell was discharged to .50 volts.

(6) Capacity Checks and Post Cycling: Average capacity of the four unfailed cells was 13.14 ah when the pack was discontinued, which is a loss of 30 percent from that of shadow 1. Also, the percentage of capacity obtained below the 1.00 volt level ranged from a low of 10.6 percent (cell 3) to a high of 37.0 percent (cell 4). This percent was 3.3 for the precycling and shadow 1 checks. Capacities of the four unfailed cells averaged 11.3 ampere-hours following a 1.2 ampere charge for 24 hours at 20°C with a voltage limit at 1.42 v/c.

(7) Cells 1, 2, 3 and 5 were found to have leaks at the base of both terminals and fill tube, following test completion.

(8) Cell 4 was sent to GSFC and cell 2 was sent to EP. The remaining cells were disposed of.

e. Performance during Sun Periods: The pack completed 13 sun periods as it began test with a shadow period. The pack originally was to float at its voltage limit during these periods; but due to temperature increase during its' first period, the pack was placed on a trickle charge of .2 amperes during these periods. The pressures never exceeded 16 PSIA during the sun periods except when the cells were overcharged in period 5. Following is a listing of the high, average and low cell voltages at the start and end of each sun period.

Sun Periods

| | | | | | | | | | | | | | |
|-------------|-----------|----------|----------|------------|----------|----------|----------|----------|-------|-----|-------|-----|--|
| Voltages*** | Start**** | 1 | | | 2 | | | 3 | | | 4 | | |
| | | End | Start | End | Start | End | Start | End | Start | End | Start | End | |
| | | 1.426(4) | 1.399(4) | 1.405(4) | 1.392(4) | 1.413(4) | 1.371(4) | 1.374(2) | | | | | |
| | | 1.422 | 1.392 | 1.400 | 1.384 | 1.396 | 1.352 | 1.368 | | | | | |
| Low | 1.415(1) | 1.388(5) | 1.400(1) | 1.376(5) | 1.388(1) | 1.329(5) | 1.360(1) | | | | | | |
| Voltages | Start | 5 | | | 6 | | | 7 | | | 8 | | |
| | | End | Start | End | Start | End | Start | End | Start | End | Start | End | |
| | | 1.392(4) | 1.390(4) | 1.380(4,5) | 1.386(4) | 1.380(5) | 1.392(5) | 1.382(4) | | | | | |
| | | 1.375 | 1.372 | 1.368 | 1.369 | 1.364 | 1.381 | 1.361 | | | | | |
| Low | 1.360(5) | 1.356(5) | 1.354(2) | 1.355(5) | 1.350(3) | 1.366(3) | 1.346(2) | | | | | | |
| Voltages | Start | 9 | | | 10 | | | 11 | | | 12 | | |
| | | End | Start | End | Start | End | Start | End | Start | End | Start | End | |
| | | 1.406(4) | 1.408(4) | 1.378(4) | 1.368(1) | 1.389(4) | 1.400(4) | 1.380(4) | | | | | |
| | | 1.388 | 1.389 | 1.357 | 1.323 | 1.357 | 1.376 | 1.363 | | | | | |
| Low | 1.367(2) | 1.368(2) | 1.343(2) | 1.268(5) | 1.339(3) | 1.336(5) | 1.350(2) | | | | | | |
| Voltages | Start | 13 | | | | | | | | | | | |
| | | End | Start | End | Start | End | Start | End | Start | End | Start | End | |
| | | 1.390(4) | 1.393(4) | 1.375 | | | | | | | | | |
| | | 1.365 | 1.375 | 1.363(5) | | | | | | | | | |
| Low | 1.304(5) | | | | | | | | | | | | |

***--() indicates which cell

****--values on VL Float, others at .2 amps

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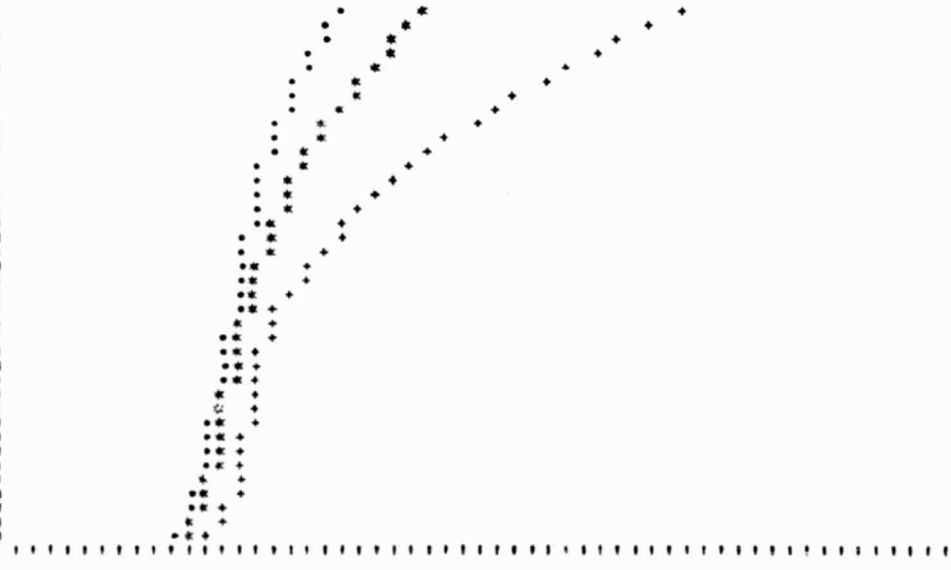
PACK NUMBER IS 221A
SHADOW PERIOD IS 10
CYCLE NUMBER IS 1965.
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KFY HIGH CELL
+ LOW CELL
* AVERAGE

2. 1.70 3.16 4.52 6.07 7.53 8.99 9.23
.97 2.43 3.89 5.35 6.80 8.26

C A P A C I T Y C E L L V O L T A G E S C A L E



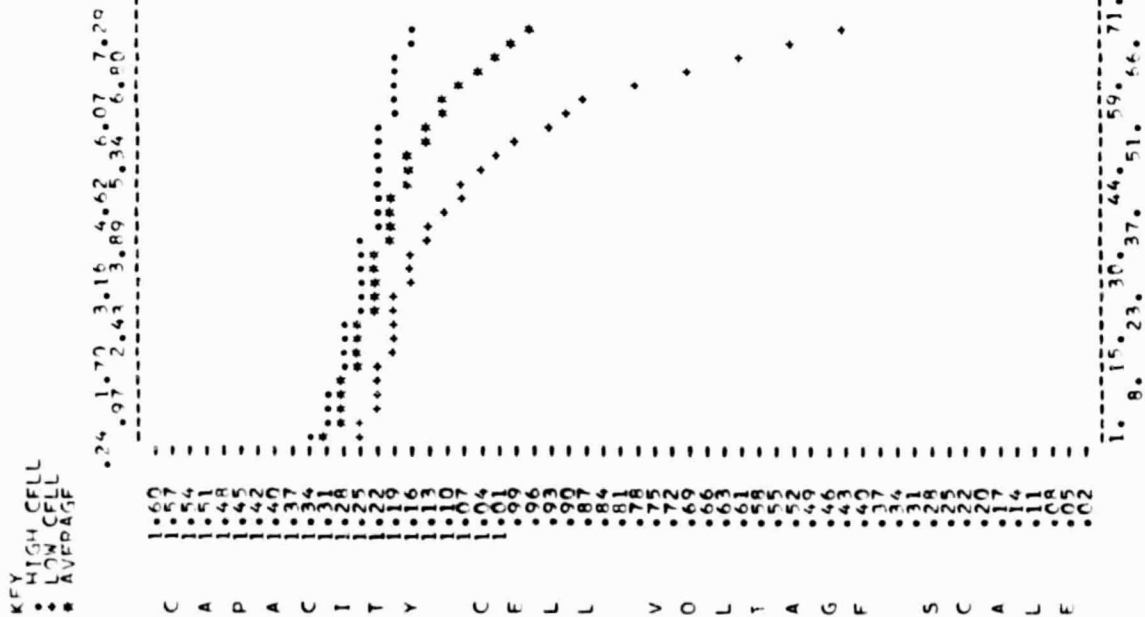
1. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 87. 90.

TIME IN MINUTES
CALLS INCLUDED VI V2 V3 V4 V5

FIGURE 140

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PACK NUMBER IS 2214
SWAMP PERIOD IS 11
CYCLE NUMBER IS 2146
DISCHARGE RATE IS 6.
AMPERE MOUNT OUT



PACK NUMBER IS 221A
SHADOW PERIOD IS 15 12
CYCLE NUMBER IS 2334.
DISCHARGE IS 56.

AMPERE H9UP OUT

| | 06 | 153 | 3.00 | 4.77 | 5.76 | 7.23 | 8.70 | 10.17 | 11.89 |
|-----|-----|------|------|------|------|------|-------|-------|-------|
| 227 | 227 | 3.74 | 5.02 | 6.50 | 7.97 | 9.44 | 10.91 | | |

C A P A C I T Y C E L L V O 177 A G E S C A L E
 0.27 0.55 0.45 0.37 0.16 0.22 0.19 0.13 0.07 0.01 0.39 0.36 0.33 0.90 0.87 0.81 0.75 0.72 0.66 0.63 0.55 0.52 0.49 0.30 0.37 0.34 0.31 0.25 0.20 0.17 0.11 0.05 0.02

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| | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|------|------|
| 11. | 16. | 30. | 44. | 59. | 73. | 87. | 102. | 119. |
| 8. | 23. | 37. | 51. | 66. | 80. | 95. | 109. | |

| TIME IN MINUTES | | CELLS INCLUDED | | | | |
|-----------------|-----|----------------|-----|-----|-----|-----|
| | | V-1 | V-2 | V-3 | V-4 | V-5 |
| 1 | 10 | | | | | |
| 2 | 20 | | | | | |
| 3 | 30 | | | | | |
| 4 | 40 | | | | | |
| 5 | 50 | | | | | |
| 6 | 60 | | | | | |
| 7 | 70 | | | | | |
| 8 | 80 | | | | | |
| 9 | 90 | | | | | |
| 10 | 100 | | | | | |
| 11 | 110 | | | | | |
| 12 | 120 | | | | | |
| 13 | 130 | | | | | |
| 14 | 140 | | | | | |
| 15 | 150 | | | | | |
| 16 | 160 | | | | | |
| 17 | 170 | | | | | |
| 18 | 180 | | | | | |
| 19 | 190 | | | | | |
| 20 | 200 | | | | | |
| 21 | 210 | | | | | |
| 22 | 220 | | | | | |
| 23 | 230 | | | | | |
| 24 | 240 | | | | | |
| 25 | 250 | | | | | |
| 26 | 260 | | | | | |
| 27 | 270 | | | | | |
| 28 | 280 | | | | | |
| 29 | 290 | | | | | |
| 30 | 300 | | | | | |
| 31 | 310 | | | | | |
| 32 | 320 | | | | | |
| 33 | 330 | | | | | |
| 34 | 340 | | | | | |
| 35 | 350 | | | | | |
| 36 | 360 | | | | | |
| 37 | 370 | | | | | |
| 38 | 380 | | | | | |
| 39 | 390 | | | | | |
| 40 | 400 | | | | | |
| 41 | 410 | | | | | |
| 42 | 420 | | | | | |
| 43 | 430 | | | | | |
| 44 | 440 | | | | | |
| 45 | 450 | | | | | |
| 46 | 460 | | | | | |
| 47 | 470 | | | | | |
| 48 | 480 | | | | | |
| 49 | 490 | | | | | |
| 50 | 500 | | | | | |
| 51 | 510 | | | | | |
| 52 | 520 | | | | | |
| 53 | 530 | | | | | |
| 54 | 540 | | | | | |
| 55 | 550 | | | | | |
| 56 | 560 | | | | | |
| 57 | 570 | | | | | |
| 58 | 580 | | | | | |
| 59 | 590 | | | | | |
| 60 | 600 | | | | | |
| 61 | 610 | | | | | |
| 62 | 620 | | | | | |
| 63 | 630 | | | | | |
| 64 | 640 | | | | | |
| 65 | 650 | | | | | |
| 66 | 660 | | | | | |
| 67 | 670 | | | | | |
| 68 | 680 | | | | | |
| 69 | 690 | | | | | |
| 70 | 700 | | | | | |
| 71 | 710 | | | | | |
| 72 | 720 | | | | | |
| 73 | 730 | | | | | |
| 74 | 740 | | | | | |
| 75 | 750 | | | | | |
| 76 | 760 | | | | | |
| 77 | 770 | | | | | |
| 78 | 780 | | | | | |
| 79 | 790 | | | | | |
| 80 | 800 | | | | | |
| 81 | 810 | | | | | |
| 82 | 820 | | | | | |

FIGURE 142

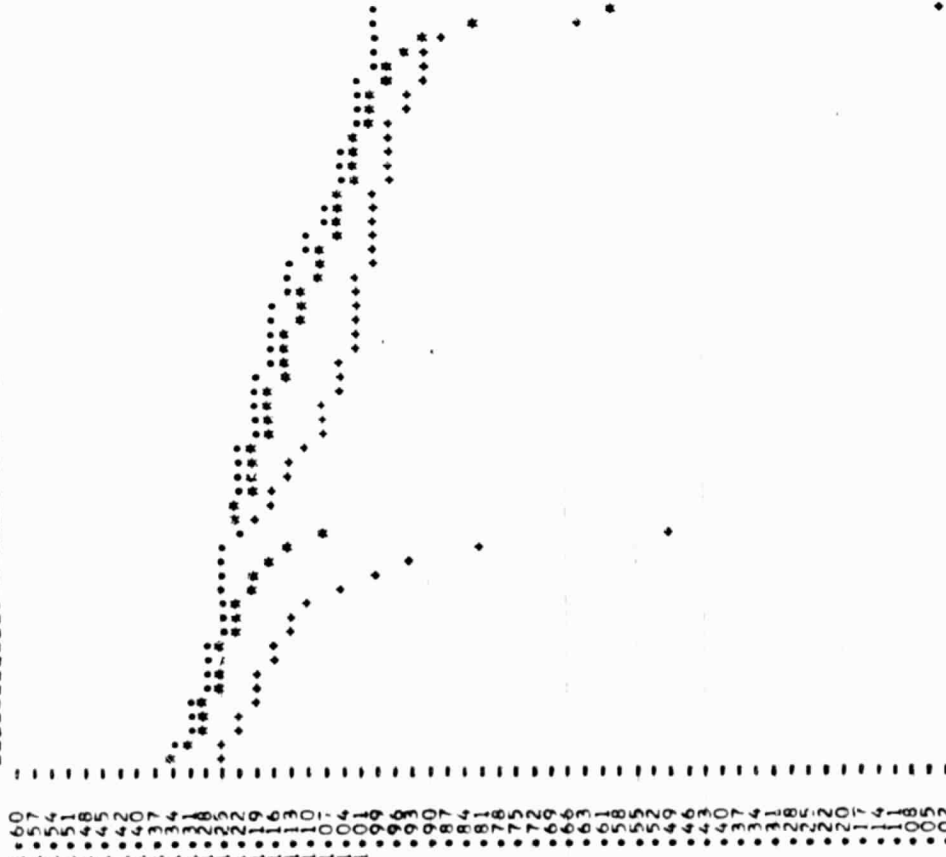
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 221A
 SHADOW PERIOD IS 13
 CYCLE NUMBER IS 02470
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

12 1.53 2.94 4.35 5.77 7.18 8.59 10.00 11.64 12.82
 .82 2.24 3.65 5.06 6.47 7.88 9.29 10.70 12.35

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 23. 30. 37. 47. 54. 61. 68. 75. 83. 90. 97. 104. 121. 133.
 128.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 143

ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

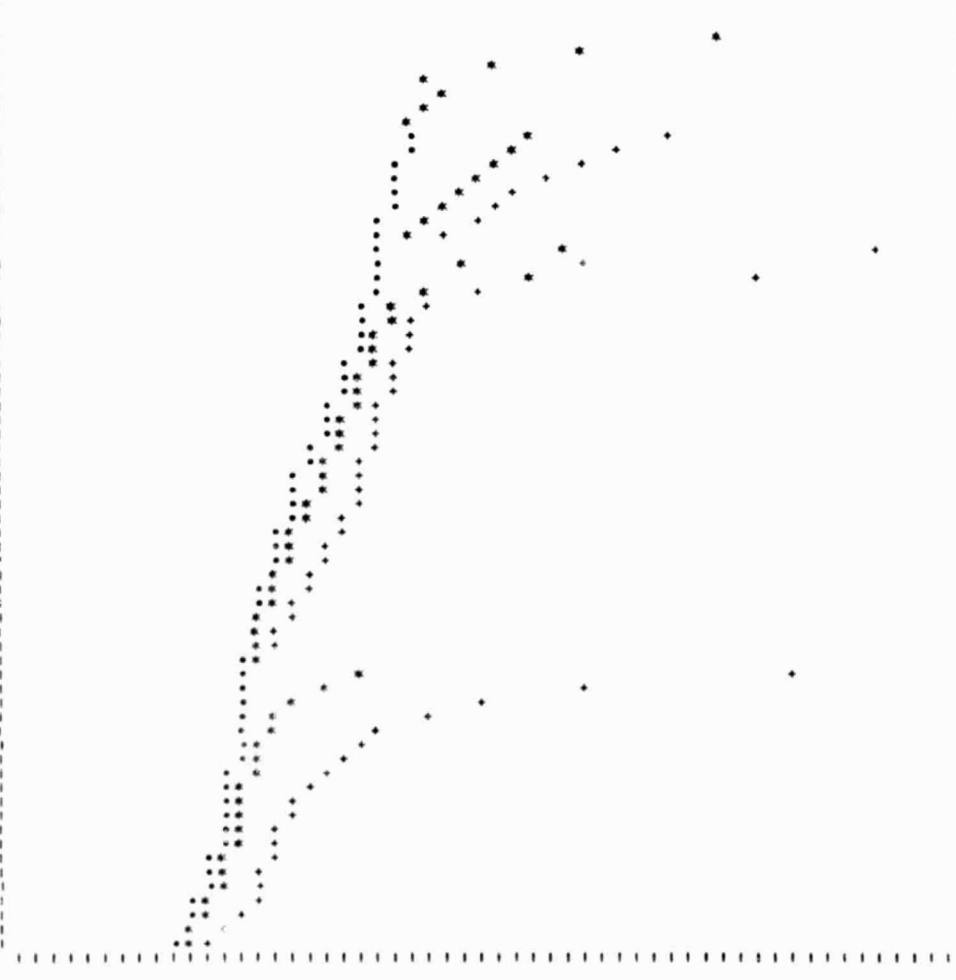
PACK NUMBER IS 221A
 SHADOW PERIOD IS 14
 CYCLE NUMBER IS 2653
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

1. 1.61 3.09 4.57 5.87 7.36 8.84 10.33 11.69 12.98 14.34 15.34
 .86 2.35 3.83 5.13 6.61 8.10 9.58 11.07 12.24 13.72 15.09

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-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
-42
-45
-48
-51
-54
-57
-60



1. 8. 15. 24. 30. 37. 44. 51. 59. 73. 87. 102. 116. 131. 145. 155.
 .86 2.35 3.83 5.13 6.61 8.10 9.58 11.07 12.24 13.72 15.09

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 144

ORIGINAL PAGE IS
 OF POOR QUALITY

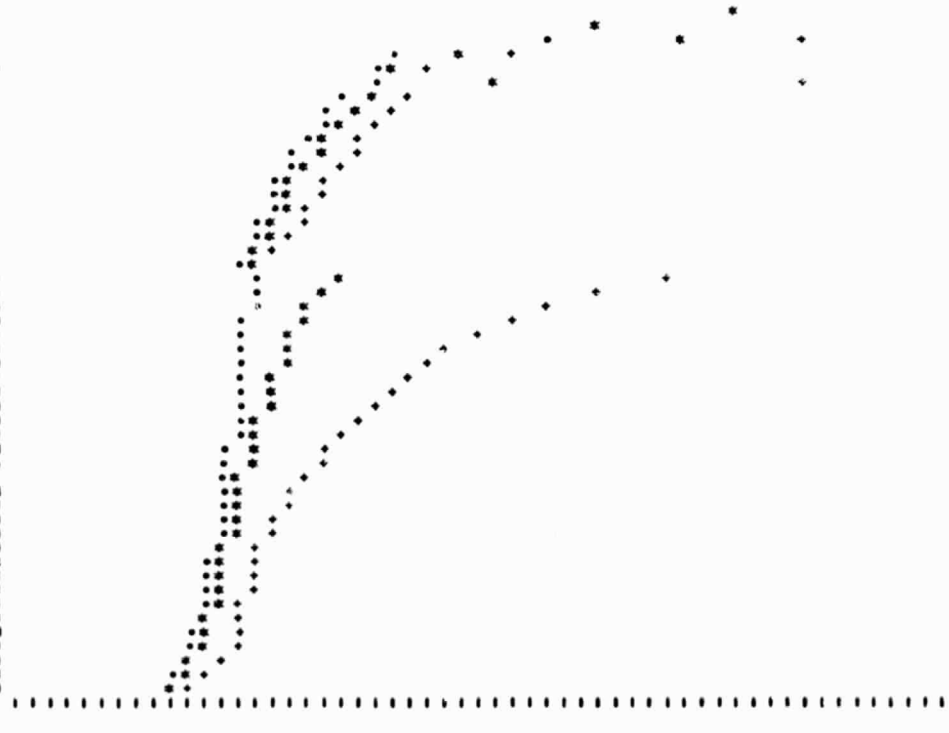
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 221A
 POST CYCLING
 CYCLE NUMBER IS 2654
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

.18 1.66 3.15 4.63 6.11 7.47 8.95 10.43 11.54
 .92 2.40 3.89 5.37 6.85 8.21 9.69 10.99

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ORIGINAL PAGE IS
 OF POOR QUALITY

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 145

* HIGH END DISCHARGE VOLTAGE
 * LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 * LOW EOC
 * AVE EOC
 * AVE EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 EAGLE PITCHER CELLS

SERIAL 001 007 011 012 013

PACK = 221A

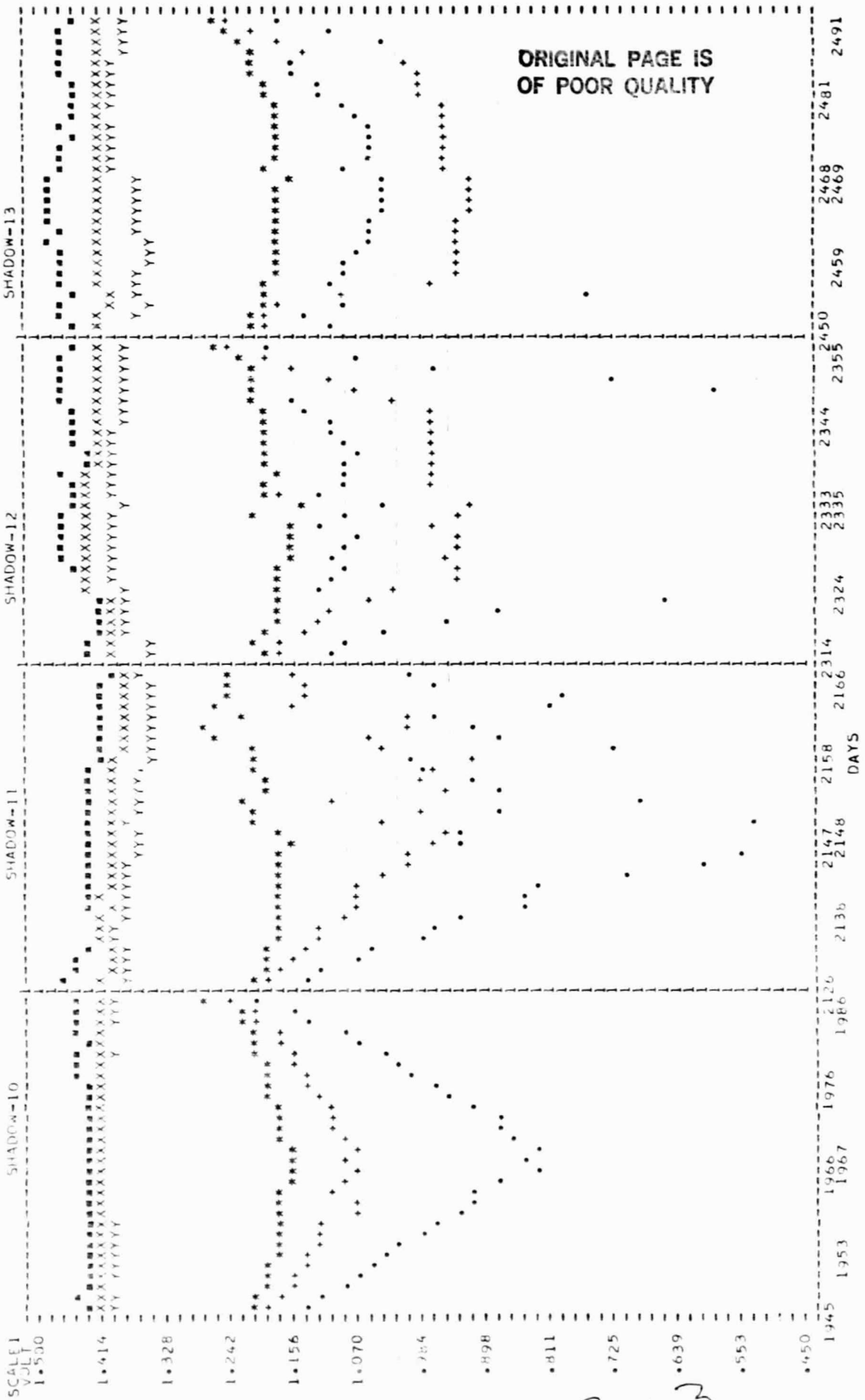


FIGURE 146

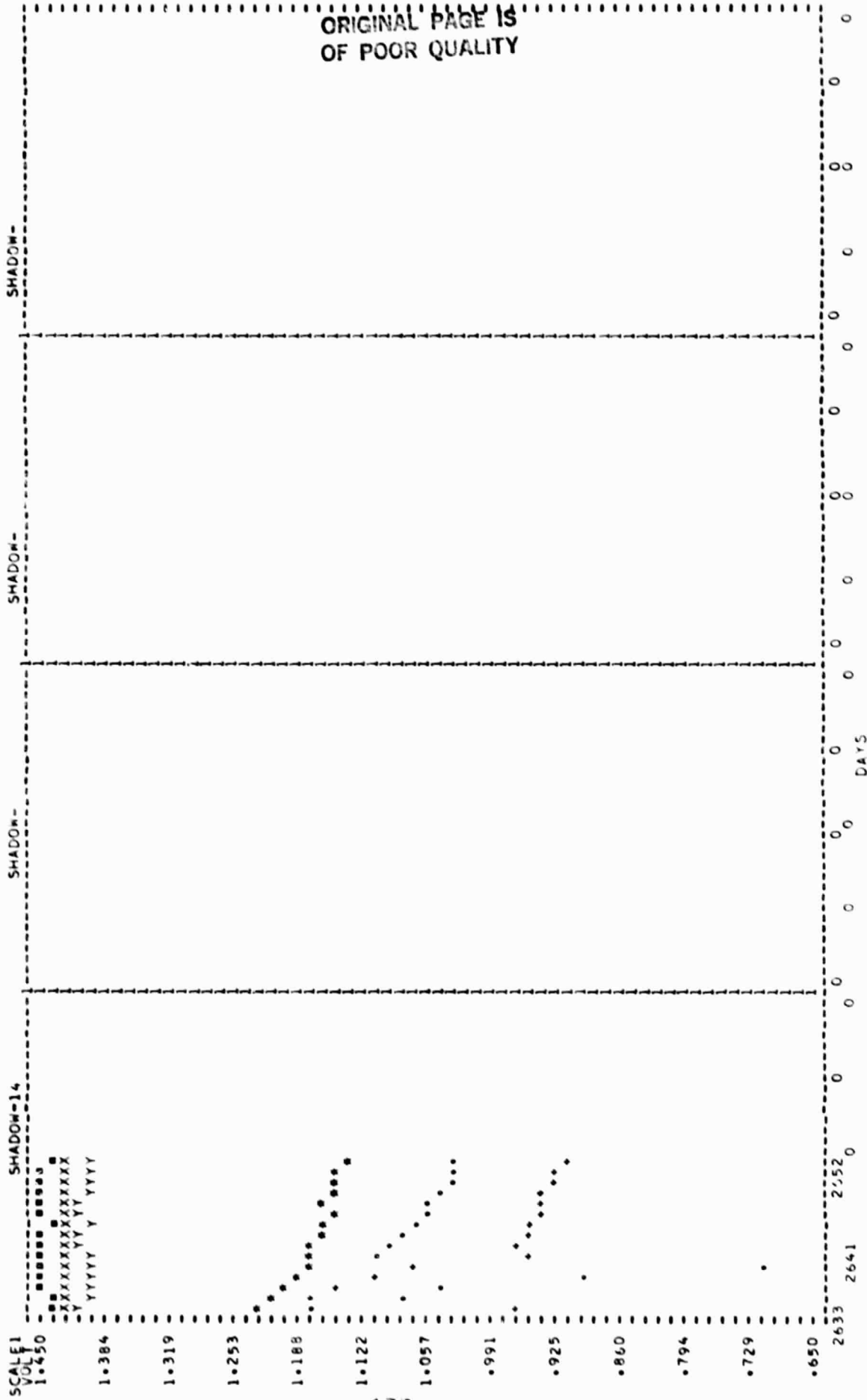
KEY
 * HIGH END DISCHARGE VOLTAGE
 * AVE END DISCHARGE VOLTAGE
 * LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 * AVE EOC
 * LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 EAGLE PITCHER CELLS

SERIAL 001 007 011 012 013

PACK = 221A



DEPTM DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 20
 AMPERE RATE 12
 EAGLE PITCHER CELLS
 SERIAL 001 007 011 012 013

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 221A

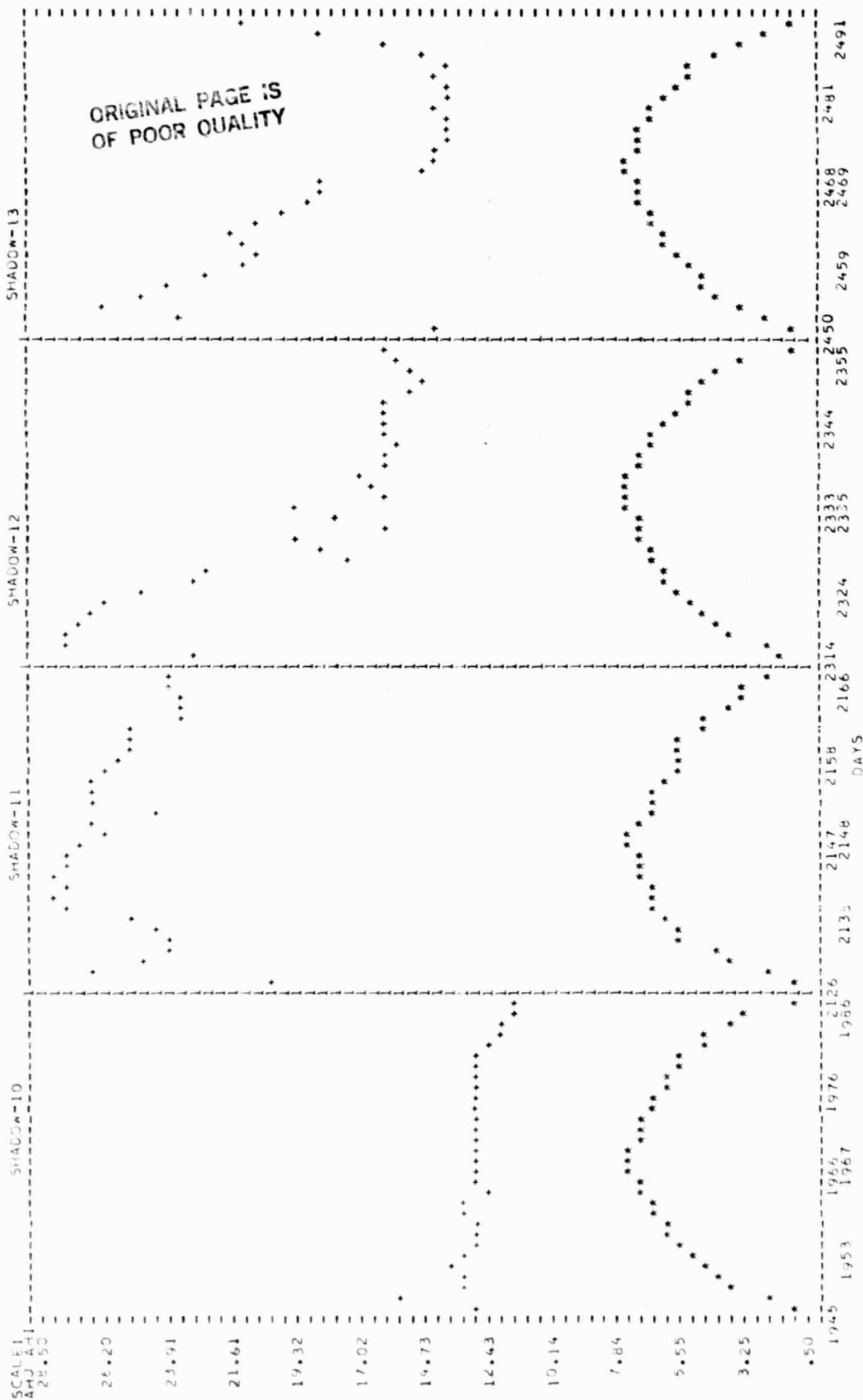


FIGURE 148

KEY
 * AHQ-TOTAL
 • AHQ-CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 EAGLE PITCHER CELLS
 SERIAL 001 007 011 012 013

PACK = 221A

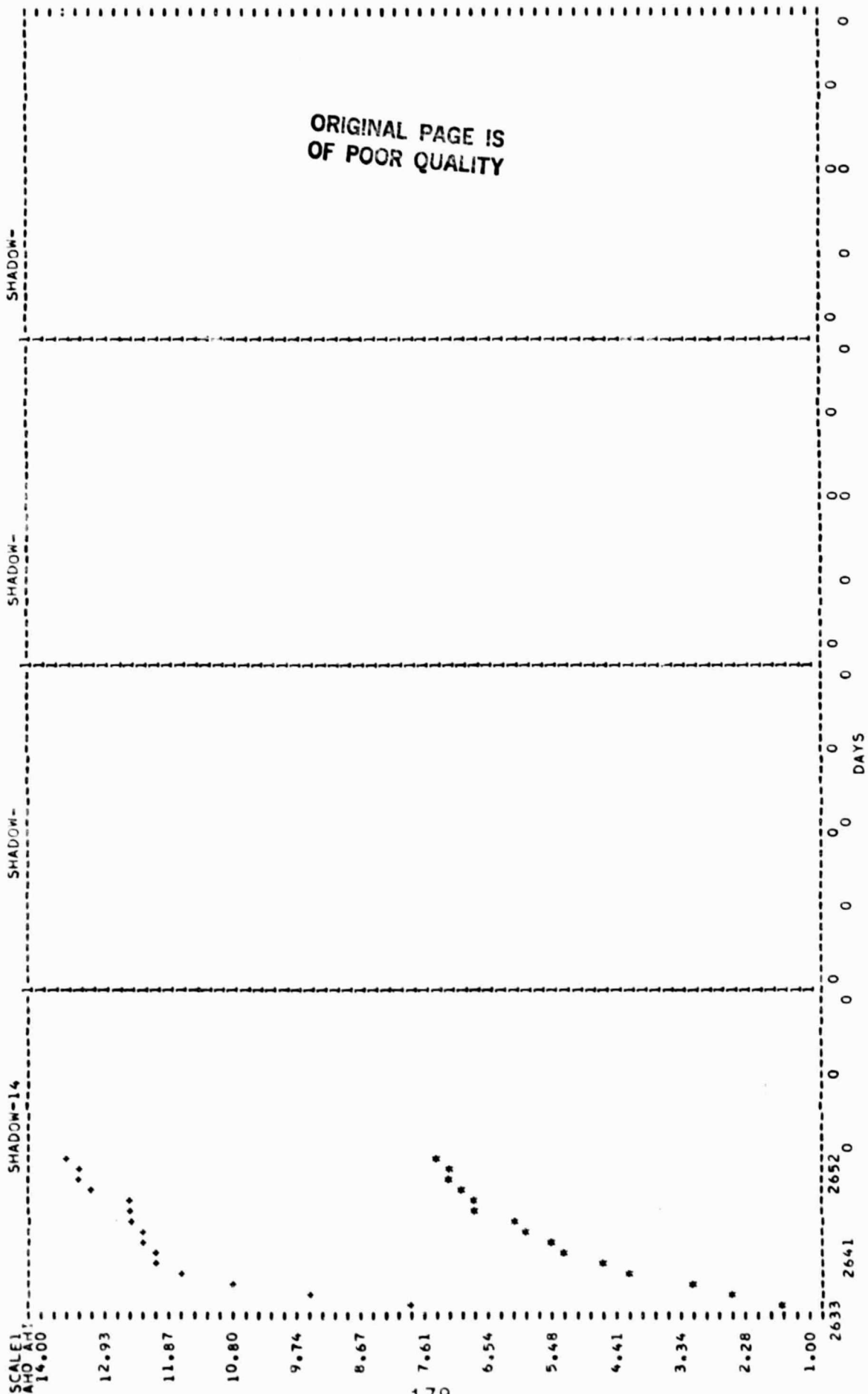


FIGURE 149

SCALE 1
CURR
1.300

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 221A

SHADOW-10

SHADOW-11

SHADOW-12

SHADOW-13

EAGLE PICHER CELLS

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 12
SERIAL 001 007 011 012 013

ORIGINAL PAGE IS
OF POOR QUALITY

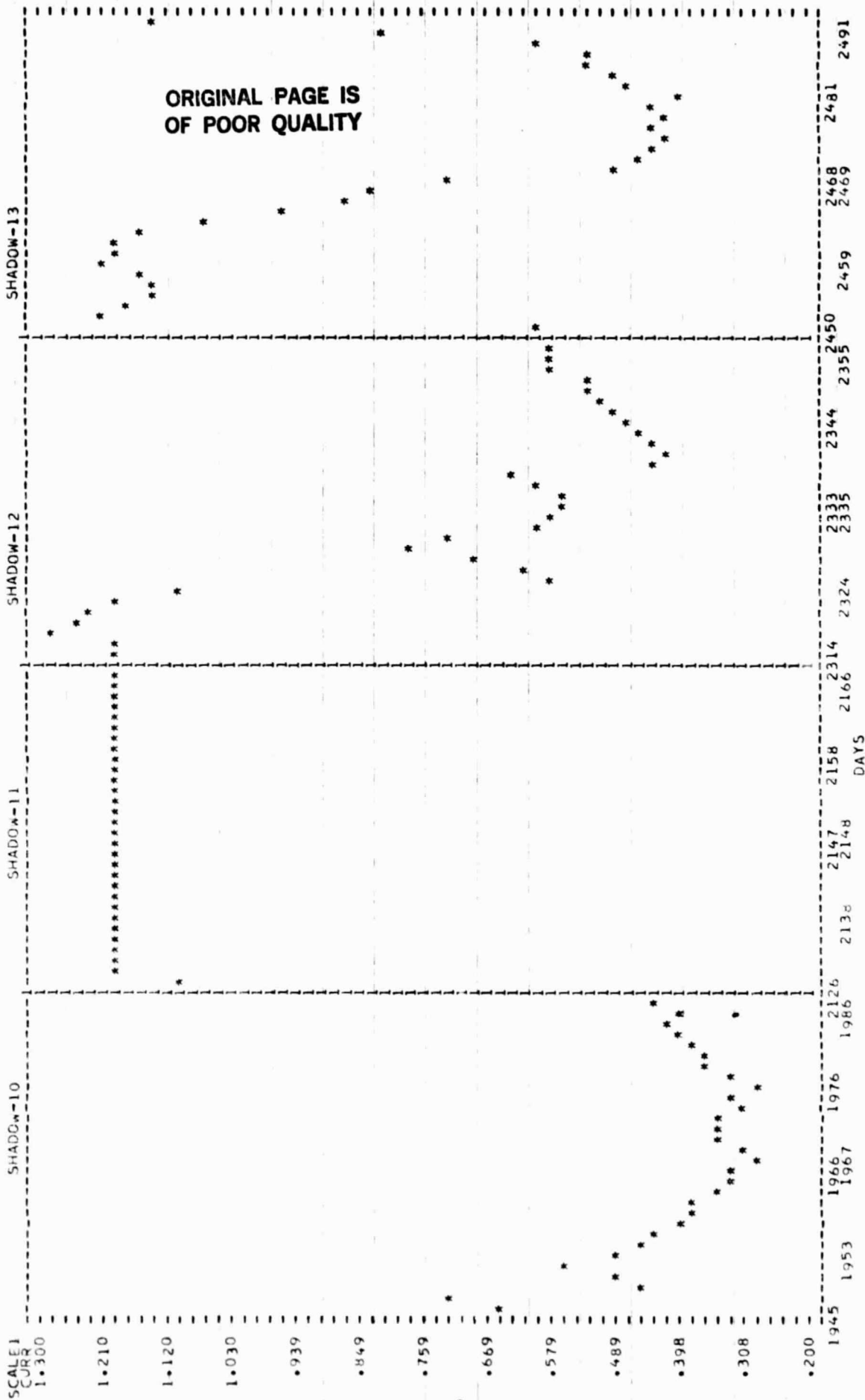


FIGURE 150

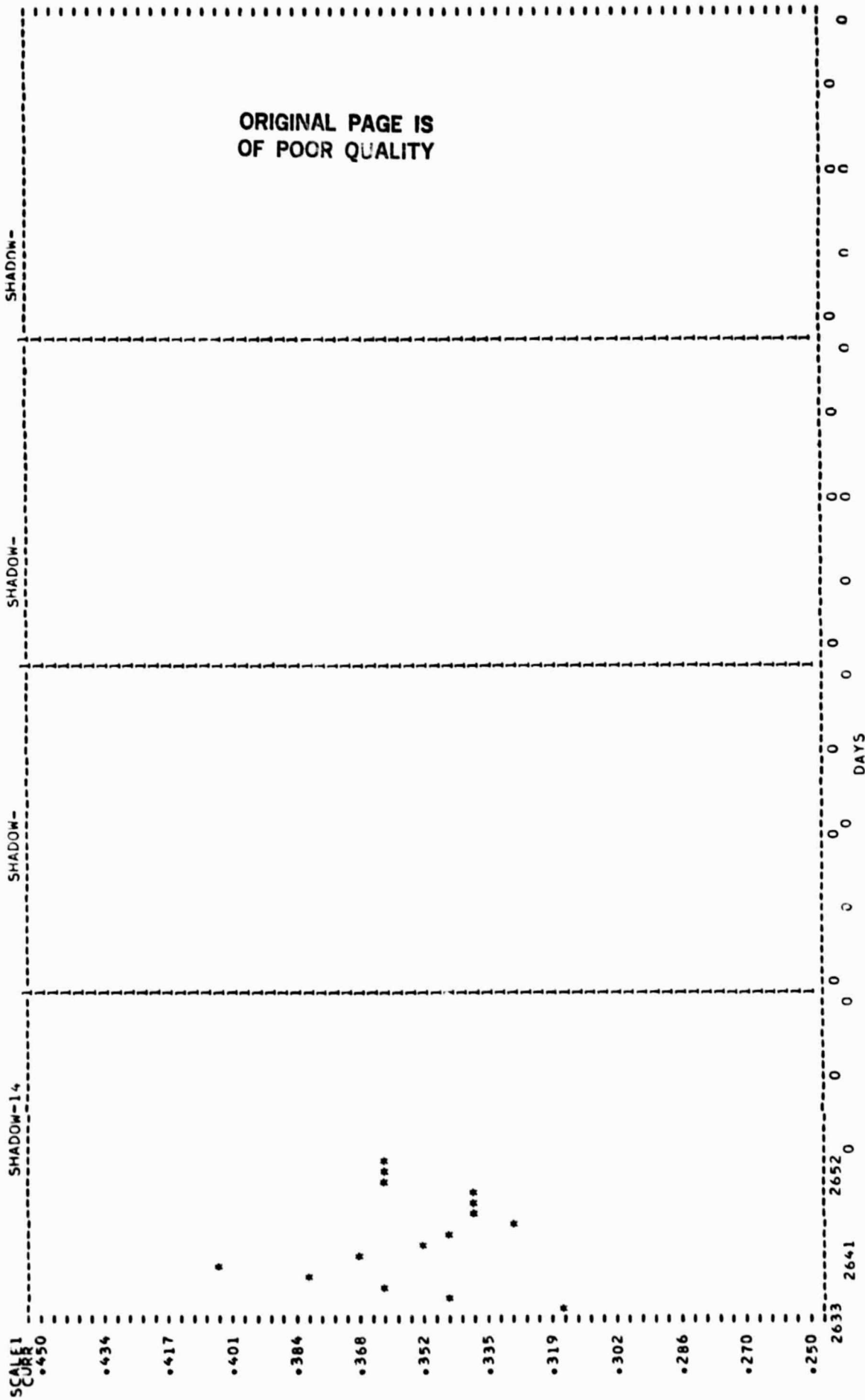
KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 W0EC/C 81-120A
TEMPERATURE 20
AMPERE RATE 12
SERIAL 001 007 011 012 013

EAGLE PITCHER CELLS

PACK = 221A



2. Pack 222A, 5-cells

a. Cell information: (Same as pack 221A, Section V.E.1.)

b. Parameters:

| | | | |
|--------------------------|-------|----------------------|-------|
| Depth of Discharge (%) | 60 | Temperature (°C) | 10 |
| Charge Control | VL | Float Voltage (v/c)* | 1.457 |
| Charge Current (amps) | 1.20 | Auxiliary Electrode: | |
| Discharge Current (amps) | 6.00 | Resistance (ohms) | 20 |
| Voltage Limit (v/c) | 1.457 | | |

*--Placed on .20 ampere constant current charge beginning with sun period 7 due to pack overcharging.

c. Capacity Checks: (Discharge to .50 volts any cell)

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell
5 | ah
out |
|------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Precycling | .756 | .864 | .500 | .900 | .872 | 15.70 |
| Shadow 1 | .714 | .909 | .782 | .826 | .696 | 16.21 |
| Shadow 2 | .841 | .977 | .700 | .561 | .979 | 17.38 |
| Shadow 3 | .471 | .903 | .475 | .073 | .922 | 17.64 |
| Shadow 4 | .627 | .839 | .732 | .424 | .907 | 17.94 |
| Shadow 5 | .534 | .769 | .592 | .221 | .845 | 18.06 |
| Shadow 6 | 1.079 | 1.037 | 1.088 | 1.086 | .481 | 13.39 |
| Shadow 7 | 1.165 | 1.068 | 1.162 | 1.170 | .470 | 10.52 |
| Shadow 8 | 1.171 | 1.128 | 1.173 | 1.176 | .476 | 8.81 |
| Shadow 9 | .566 | .421 | .676 | .954 | ** | 17.28 |
| Shadow 10 (Figure 152) | .481 | .533 | .597 | .911 | | 17.37 |
| Shadow 11 (Figure 153) | .411 | .443 | .487 | .863 | | 18.87 |
| Shadow 12 (Figure 154) | .515 | .497 | .547 | .861 | | 17.18 |
| Shadow 13 (Figure 155) | .470 | .475 | .511 | .823 | | 17.05 |
| Shadow 14 (Figure 156) | 17.16 | 17.16 | 17.16 | 17.66 | | |
| Post
Cycling (Figure 157) | 15.38 | 15.38 | 15.57 | 1.41 | | |

**--Cell 5 leaking, discontinued during capacity check, 5.5 ah out.

d. Test results during the Shadow Periods: (Figures 158 to 163)

(1) End of Discharge Voltages: There was a sharp decrease in the low EOD voltages during shadow 6 as compared to the previous shadows. This decline can be attributed to the "drying out" of cell 5. The pack was transferred, following eclipse season 3, from the old data system to the new computer controlled data acquisition system. While rewiring the pack, a small hole was created in the seal of cell 5 while soldering. This hole was potted and the cell allowed to remain in the pack. The cell was checked, at the beginning of shadow 6, and found to be leaking. This cell was removed (shadow 9) during the capacity check in which it delivered 5.5 ah.

The reconditioning effect, due to the capacity checks, was very evident for the first 5 shadows; but then diminished as cell 5 was the limiting cell and prevented the other cells from being discharged below 1.00 volts. This effect again became significant during shadow 9, following cell 5's removal from test.

(2) End of Charge Voltages: The cells were always unbalanced at the end of charge. Cell 5 began to exhibit the highest voltage during shadow 6 which indicates it was "drying out". Typically, the cell divergence is greatest at the start of the shadows and least in the middle.

(3) Ampere-Hours Input: The input is high at the beginning of shadows 6 and 7 due to the pack being charged at 1.2 amperes constantly at the end of the sun periods preceeding these shadow periods. The high input at the beginning of shadow 8 is due to the pack not being fully charged at the start of its shadow period. The ampere-hour input at the beginning of shadow 9 is normal, due to the pack being trickle charged at .2 amperes during the sun period prior to shadow 9. This ampere-hour input, normally can be related to the cell voltage divergence in that the input decreases as the cell voltage divergence decreases.

(4) Pressures at End of Charge: Pressures did not exceed 25 psia during any eclipse season. Cell 5 did not indicate a change in pressure following the sun period prior to shadow 6.

(5) The pack was discontinued in the middle of shadow 14 in which each cell was discharged to .50 volts.

(6) Capacity Checks and Post Cycling: Average capacity was 17.78 ah when the pack was discontinued and 16.3 percent of this was below the 1.00 volt level which is double that obtained during precycling and shadow 1. The capacities of cells 1, 2 and 3 were slightly lower than their precycling capacity following a 1.2 ampere charge for 24 hours at 10°C with a voltage limit of 1.457 v/c. Cell 4 shorted during the capacity test. During the charge, before the capacity test, its voltage peaked at 1.440 volts after 21 hours of charge, and then steadily decreased to 1.424 volts at the end of charge.

(7) Cells 3 and 4 were found to have leaks at the base of both terminals, and cell 2 at its positive terminal, following test completion.

(8) Cell 5 was sent to GSFC and cell 2 to EP. The remaining cells were disposed of.

e. Performance during Sun Periods: The pack completed 13 sun periods as it began test with a shadow period. The pack floated at its voltage limit for the first 4 periods. At the end of periods 5 and 6 it was charging at 1.2 amperes due to temperature increase and was below its voltage limit. Following period 6, the pack was placed on a .2 ampere trickle charge for the sun periods. The pressures always indicated a vacuum during the float periods, even when the cells were being overcharged. Following is a listing of the high, average, and low cell voltages and current (amps) at the start and end of each sun period.

Sun Periods

| | | 1 | | 2 | | 3 | | 4 | | 7**** | | 8 | | 11 | | 12 | | 13 | |
|-------------|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | Start | End | Start | End | Start | End | Start | End | Start | End | Start | End | Start | End | Start | End | Start | End |
| Voltages*** | | 1.474(4) | 1.480(4) | 1.481(4) | 1.485(4) | 1.455(4) | 1.455(4) | 1.513(4) | 1.488(4) | 1.487(5) | 1.397(2) | 1.443(5) | 1.403(2) | 1.417(2) | 1.381(4) | 1.403(2) | 1.404(1) | 1.407(4) | 1.406(2) |
| High | | 1.458 | 1.457 | 1.459 | 1.457 | 1.455 | 1.457 | 1.459 | 1.458 | 1.453 | 1.383 | 1.411 | 1.397 | 1.406 | 1.375 | 1.397 | 1.397 | 1.403 | 1.395 |
| Average | | 1.431(2) | 1.430(5) | 1.446(2) | 1.440(5) | 1.447(2) | 1.436(5) | 1.434(5) | 1.427(5) | 1.428(3) | 1.376(3) | 1.397(1) | 1.385(1) | 1.399(1) | 1.362(2) | 1.385(1) | 1.385(1) | 1.399(1) | 1.390(1) |
| Low | | .12 | .17 | .15 | .19 | .13 | .22 | .19 | .51 | | | | | | | | | | |
| Current | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| Voltages | | 1.510(4) | 1.478(2) | 1.491(5) | 1.450(2) | 1.487(5) | 1.450(2) | 1.443(5) | 1.404(1) | 1.487(5) | 1.397(2) | 1.443(5) | 1.403(2) | 1.417(2) | 1.381(4) | 1.403(2) | 1.404(1) | 1.407(4) | 1.406(2) |
| High | | 1.457 | 1.446 | 1.454 | 1.424 | 1.453 | 1.424 | 1.411 | 1.311 | 1.453 | 1.383 | 1.411 | 1.397 | 1.406 | 1.375 | 1.397 | 1.397 | 1.403 | 1.395 |
| Average | | 1.432(5) | 1.420(3) | 1.430(2) | 1.411(5) | 1.428(3) | 1.411(5) | 1.397(1) | | 1.428(3) | 1.376(3) | 1.397(1) | 1.385(1) | 1.399(1) | 1.362(2) | 1.385(1) | 1.385(1) | 1.399(1) | 1.390(1) |
| Low | | .20 | 1.20 | .34 | 1.20 | | 1.20 | | | | | | | | | | | | |
| Current | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| Voltages | | 1.423(2) | 1.403(2) | 1.416(2) | 1.389(2) | 1.417(2) | 1.389(2) | 1.403(2) | 1.404(1) | 1.417(2) | 1.381(4) | 1.403(2) | 1.403(2) | 1.417(2) | 1.381(4) | 1.403(2) | 1.404(1) | 1.407(4) | 1.406(2) |
| High | | 1.411 | 1.393 | 1.410 | 1.379 | 1.406 | 1.379 | 1.397 | 1.397 | 1.406 | 1.375 | 1.397 | 1.397 | 1.406 | 1.375 | 1.397 | 1.397 | 1.403 | 1.395 |
| Average | | 1.398(4) | 1.386(4) | 1.406(3) | 1.374(1) | 1.399(1) | 1.374(1) | 1.385(1) | 1.385(1) | 1.399(1) | 1.362(2) | 1.385(1) | 1.385(1) | 1.399(1) | 1.362(2) | 1.385(1) | 1.385(1) | 1.399(1) | 1.390(1) |
| Low | | | | | | | | | | | | | | | | | | | |
| Current | | | | | | | | | | | | | | | | | | | |

***--() indicates which cell

****-- current reduced to .2 amperes at start

*****-- cells were 1.310 volts and not fully charged due to low voltage programmed on power supply

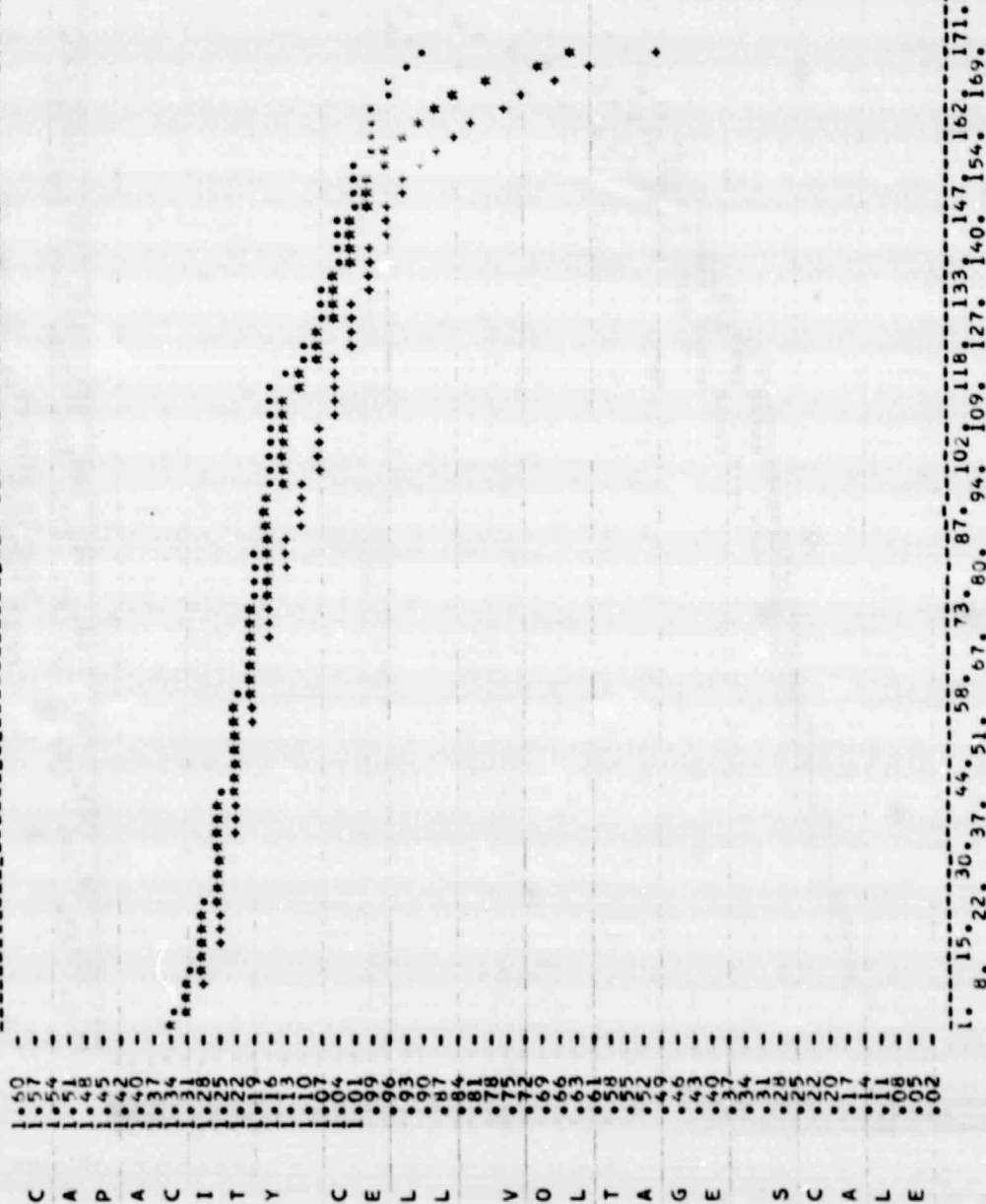
ORIGINAL PAGE IS
OF POOR QUALITY

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

BACK NUMBER IS 222A
SWADLOW PERIOD IS 10
CYCLE NUMBER IS 1965
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

2. 1.70 3.15 4.60 6.06 7.51 8.97 10.42 12.12 13.57 15.03 16.47 17.37
9. 2.42 3.88 5.33 6.79 8.24 9.69 11.15 12.84 14.30 15.75 17.15



CELLS INCLUDED VI V2 V3 V4 V5

FIGURE 152

PACK NUMBER IS 2224
 SHADON PERIOD IS 11
 CYCLE NUMBER IS 2146
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

23 1.64 3.06 7.01 8.42 9.13 10.64 11.24 12.65 14.06 15.48 16.89 17.25 18.61 19.87
 94 2.35 6.31 7.72 9.13 10.64 11.95 13.12 14.77 16.18 17.59 17.95

KFY HIGH CELL
 * LOW CELL
 * AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E
 157 154 153 152 151 150 149 148 147 146 145 144 143 142 141 140 139 138 137 136 135 134 133 132 131 130 129 128 127 126 125 124 123 122 121 120 119 118 117 116 115 114 113 112 111 110 109 108 107 106 105 104 103 102 101 100 99 98 97 96 95 94 93 92 91 90 89 88 87 86 85 84 83 82 81 80 79 78 77 76 75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

ORIGINAL PAGE IS
 OF POOR QUALITY

1. 9. 15. 23. 29. 34. 44. 51. 58. 65. 73. 80. 87. 94. 101. 109. 113. 123. 137. 152. 166. 181. 185.

TIME IN MINUTES
 CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 153

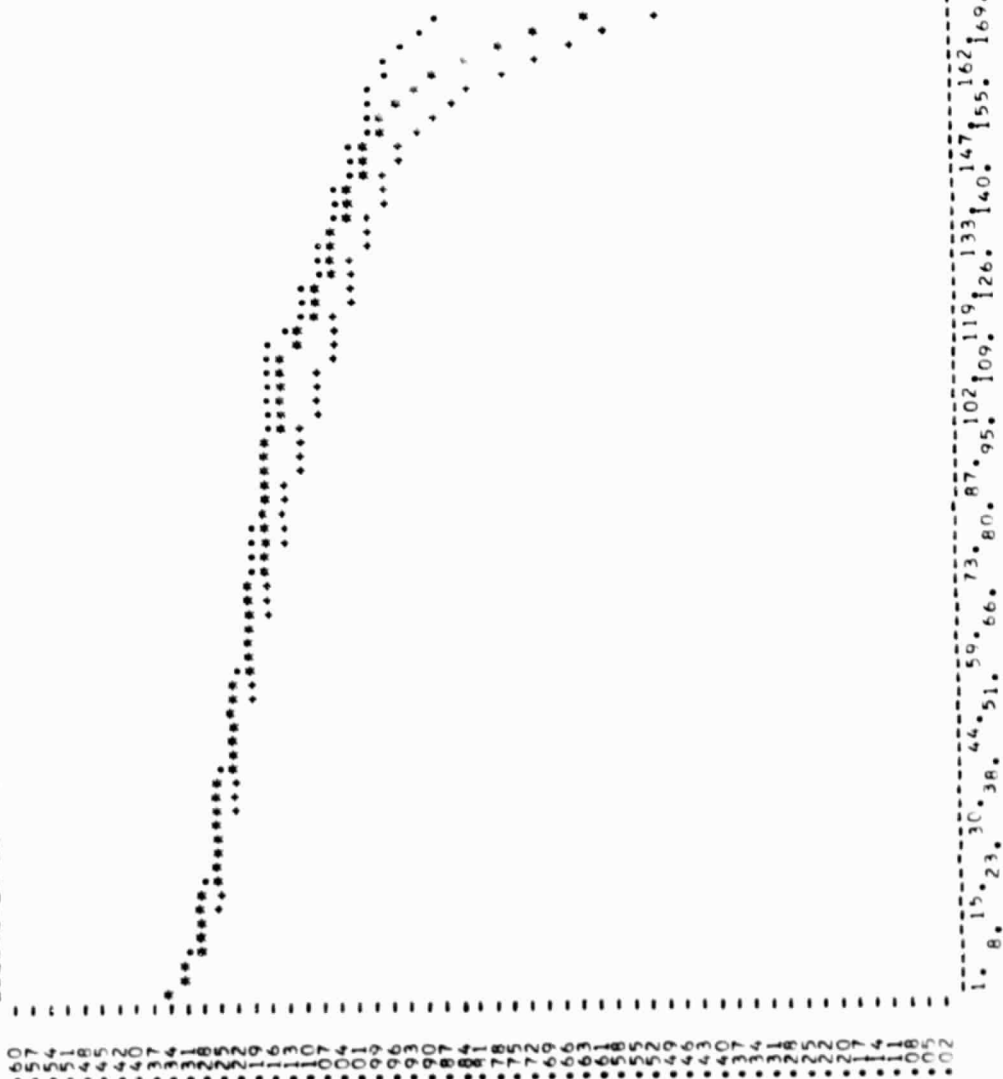
ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 222A
SHADOW NUMBER IS 2334.
CYCLE NUMBER IS 6.
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KEY HIGH CELL
• LOW CELL
• AVERAGE

24. 1.70 3.16 4.63 5.36 6.09 7.55 9.01 10.47 12.18 13.64 15.10 16.53
97. 2.43 3.89 5.36 6.82 8.28 9.74 11.20 12.91 14.38 15.82 17.19



CELLS INCLUDED V-1 V-2 V-3 V-4

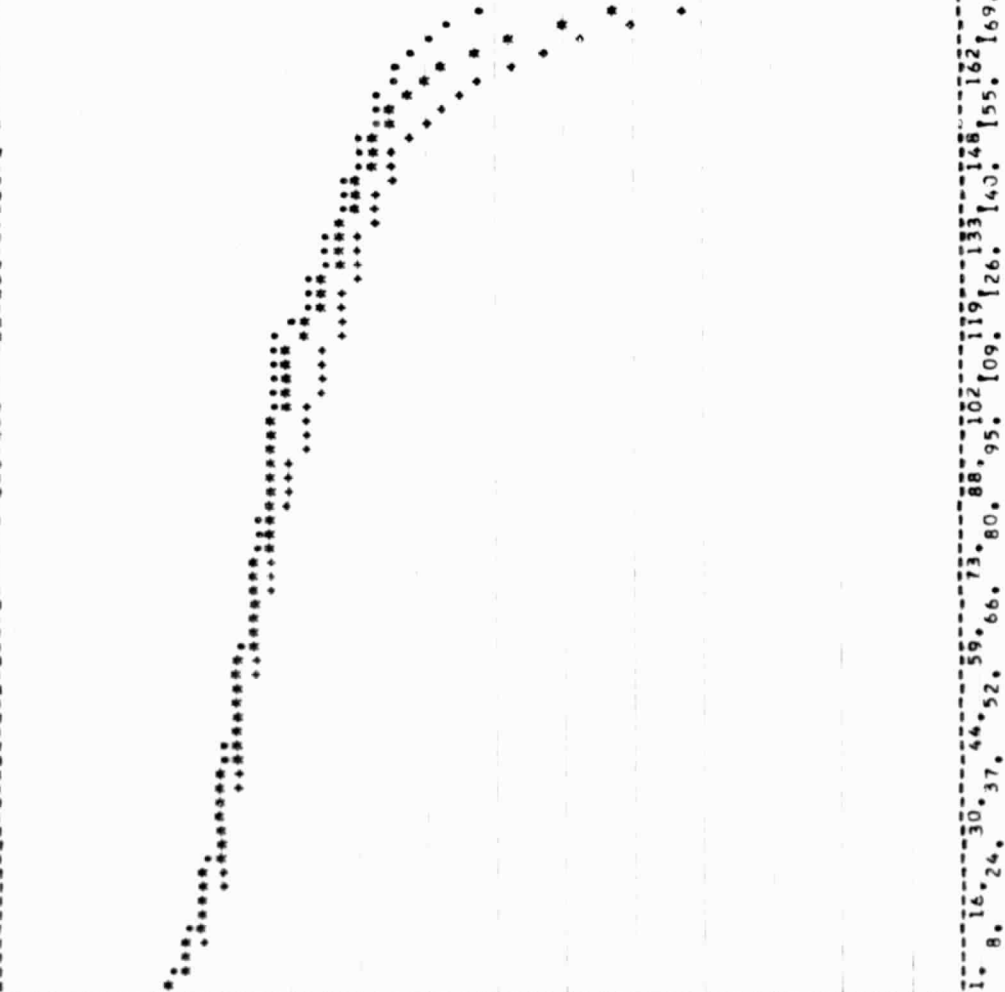
FIGURE 154

ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 222A
SHADOW PERIOD IS 13
CYCLE NUMBER IS 02470
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

12 1.59 3.02 4.51 5.98 7.44 8.90 10.37 12.08 13.54 15.00 16.41 17.85
2.32 3.78 5.24 6.71 8.17 9.64 11.10 12.81 14.27 15.72 17.05



TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4

FIGURE 155

KEY
HIGH CELL
LOW CELL
MV RANGE

C A P A C I T Y C E L L V O L T A G E S C A L E

ORIGINAL PAGE IS
OF POOR QUALITY

KEY
• HIGH CELL
+ LOW CELL
* AVERAGE

PACK NUMBER IS 222A
SHADOW PERIOD IS 14
CYCLE NUMBER IS 2653
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

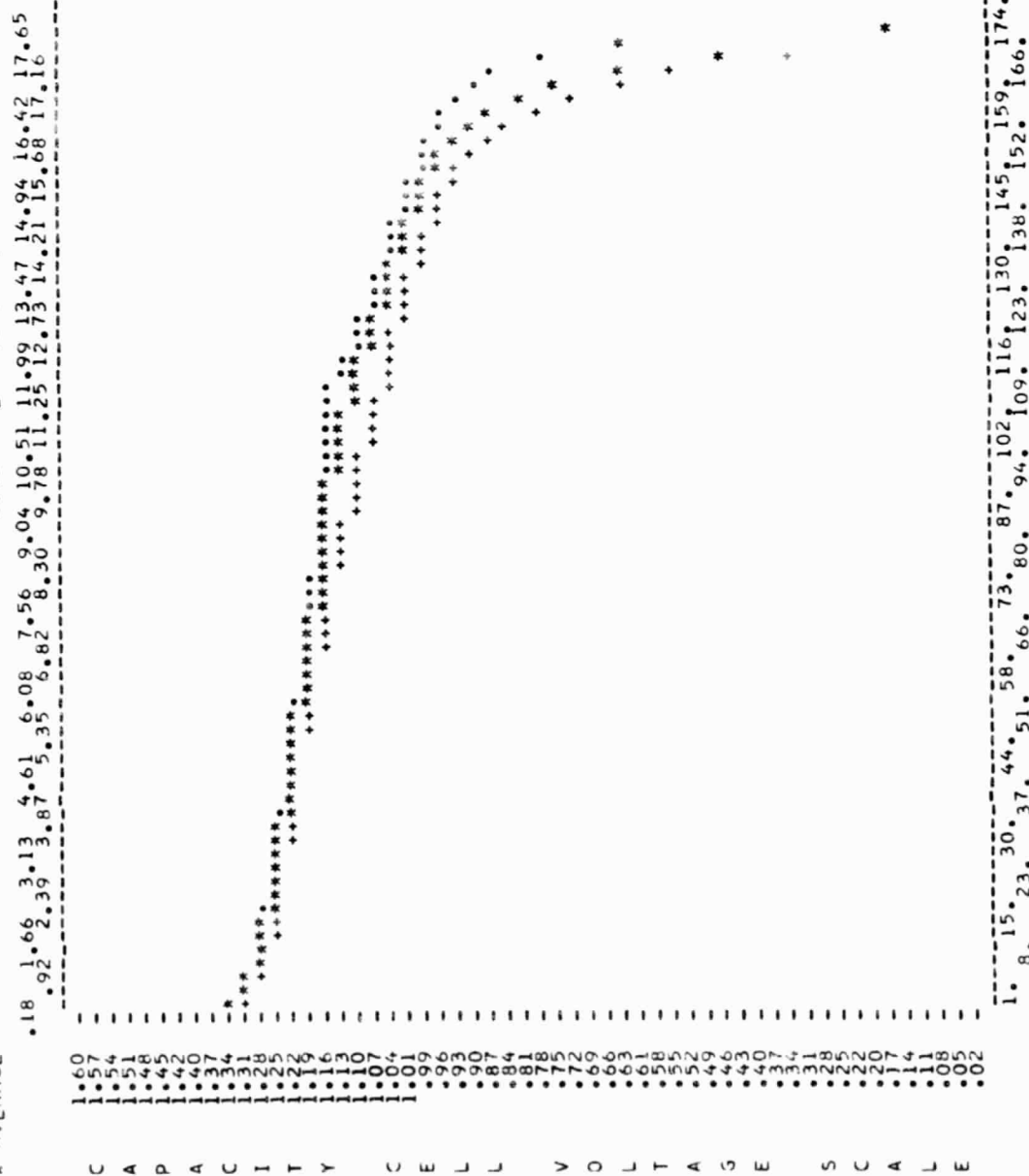


FIGURE 156

KEY HIGH CELL
 * LOW CELL
 * AVERAGE
 PACK NUMBER IS 222A
 POST CYCLING
 CYCLE NUMBER IS 2654
 DISCHARGE RATE IS 6.0
 AMPERE HOUR OUT
 18 1.41 2.89 4.37 5.78 7.26 8.73 10.21 11.69 13.16 14.64 15.57
 .92 2.15 3.63 5.04 6.52 8.00 9.47 10.95 12.43 13.90 15.38

ORIGINAL PAGE IS
OF POOR QUALITY

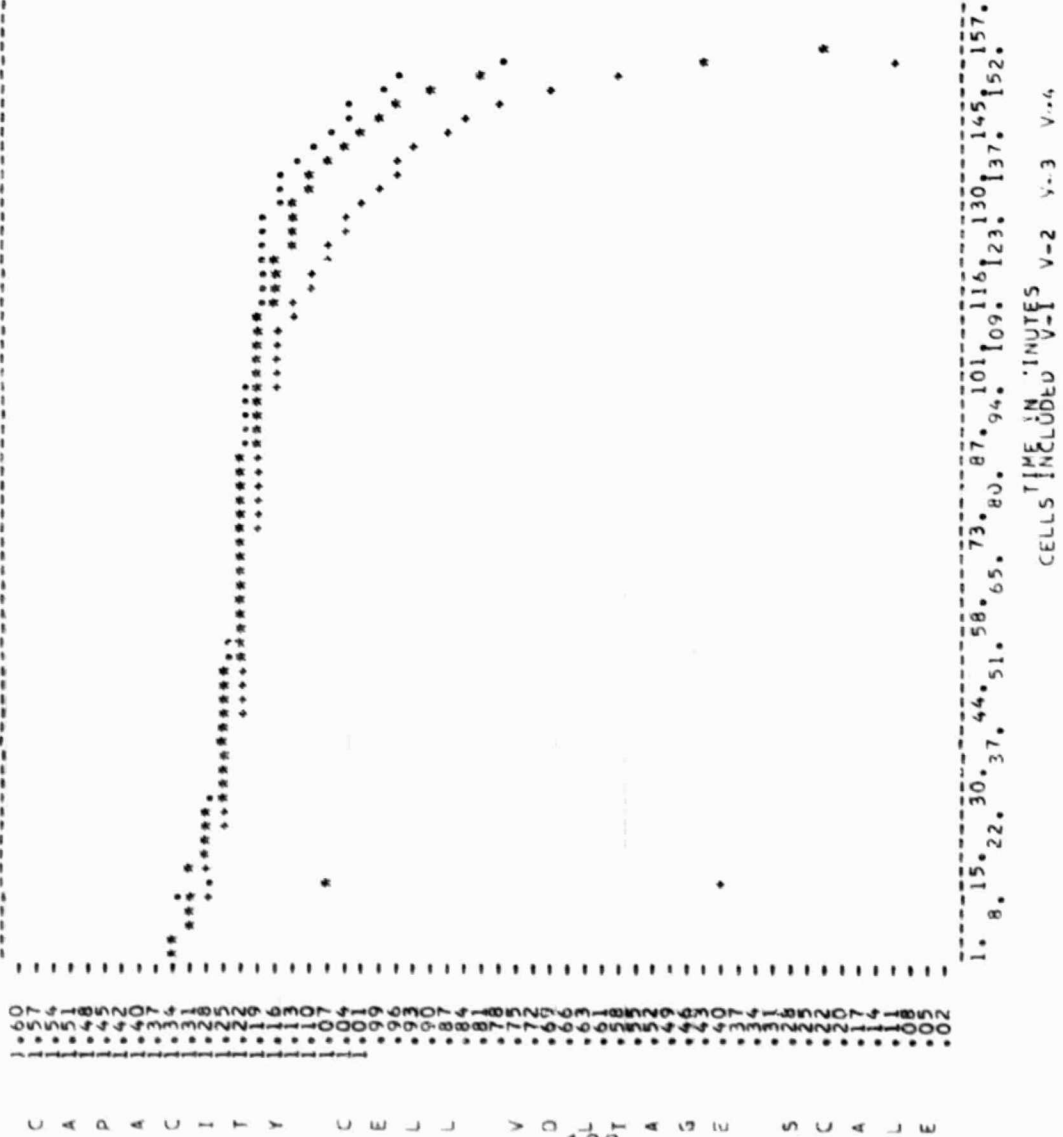


FIGURE 157

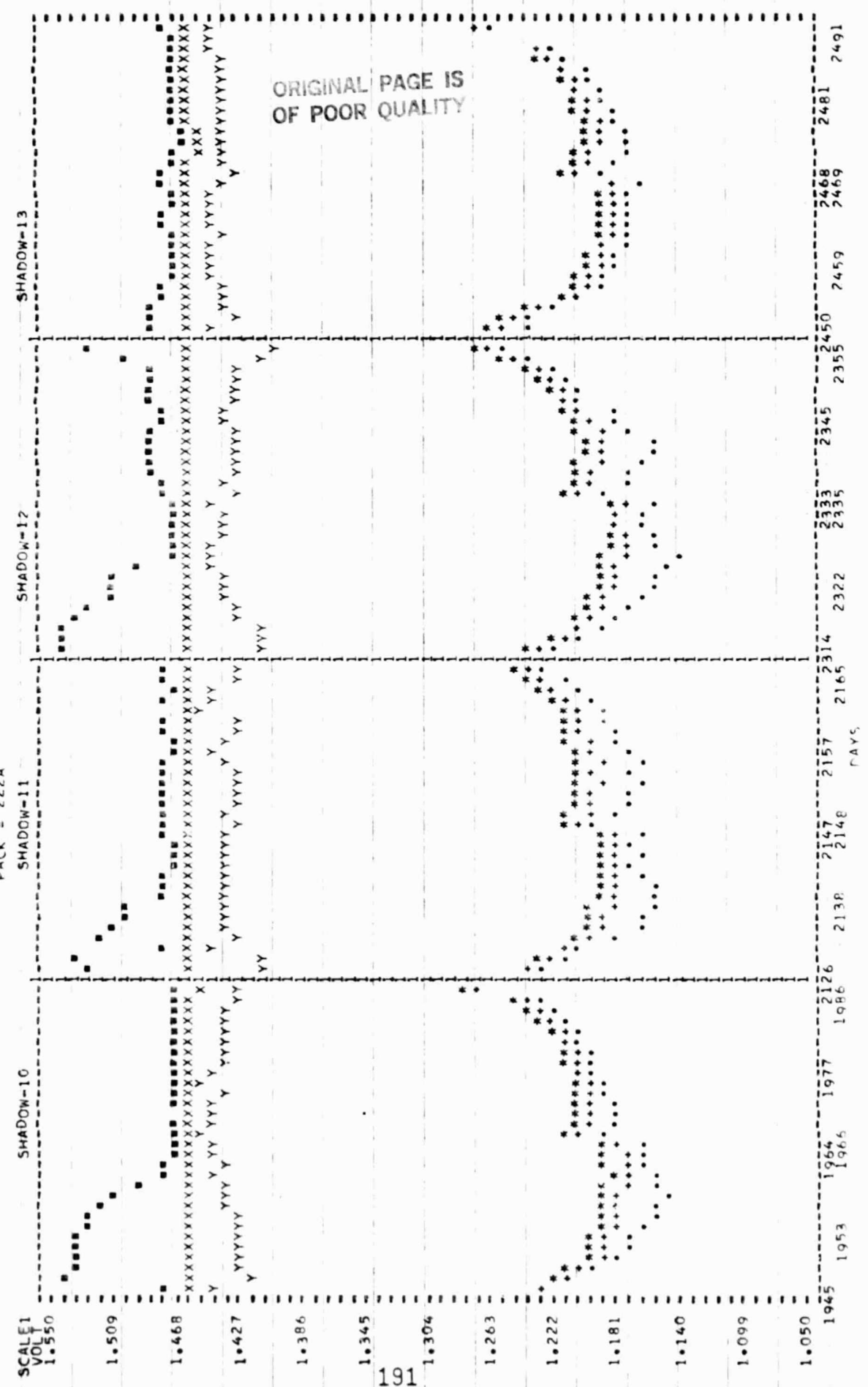
DEPTH DISCHARGE 60
 TEMPERATURE 10
 AMPERE RATE 12
 EAGLE PITCHER CELLS

SERIAL 005 002 015 014 025

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
 * HIGH
 + AVE
 . END
 x LOW
 y HIGH
 y AVE
 y LOW

PACK = 222A



SCALE 1
 VOLT
 1.550
 1.509
 1.468
 1.427
 1.386
 1.345
 1.304
 1.263
 1.222
 1.181
 1.140
 1.099
 1.050

1965 1953 1964 1966 1977 1986 2126 2138 2147 2157 2165 2314 2322 2333 2335 2345 2355 2450 2459 2468 2481 2491

DAYS

DEPTURE CHARGE 60
TEMPERATURE 10
EAGLE PITCHER 12 CELLS

SERIAL 005 002 015 014 025

WOEC/C 81-120A

SYNCHRONOUS ORBIT SHADOW PLOT

| KEY | TEST | END | DISCHARGE | VOLTAGE |
|-----|------|-----|-----------|---------|
| • | HIGH | END | DISCHARGE | VOLTAGE |
| • | AVL | END | DISCHARGE | VOLTAGE |
| • | LOW | END | DISCHARGE | VOLTAGE |
| • | HIGH | EOC | DISCHARGE | VOLTAGE |
| • | AVL | EOC | DISCHARGE | VOLTAGE |
| • | LOW | EOC | DISCHARGE | VOLTAGE |

SERIAL 005 002 015 014 025

PACK = 222A

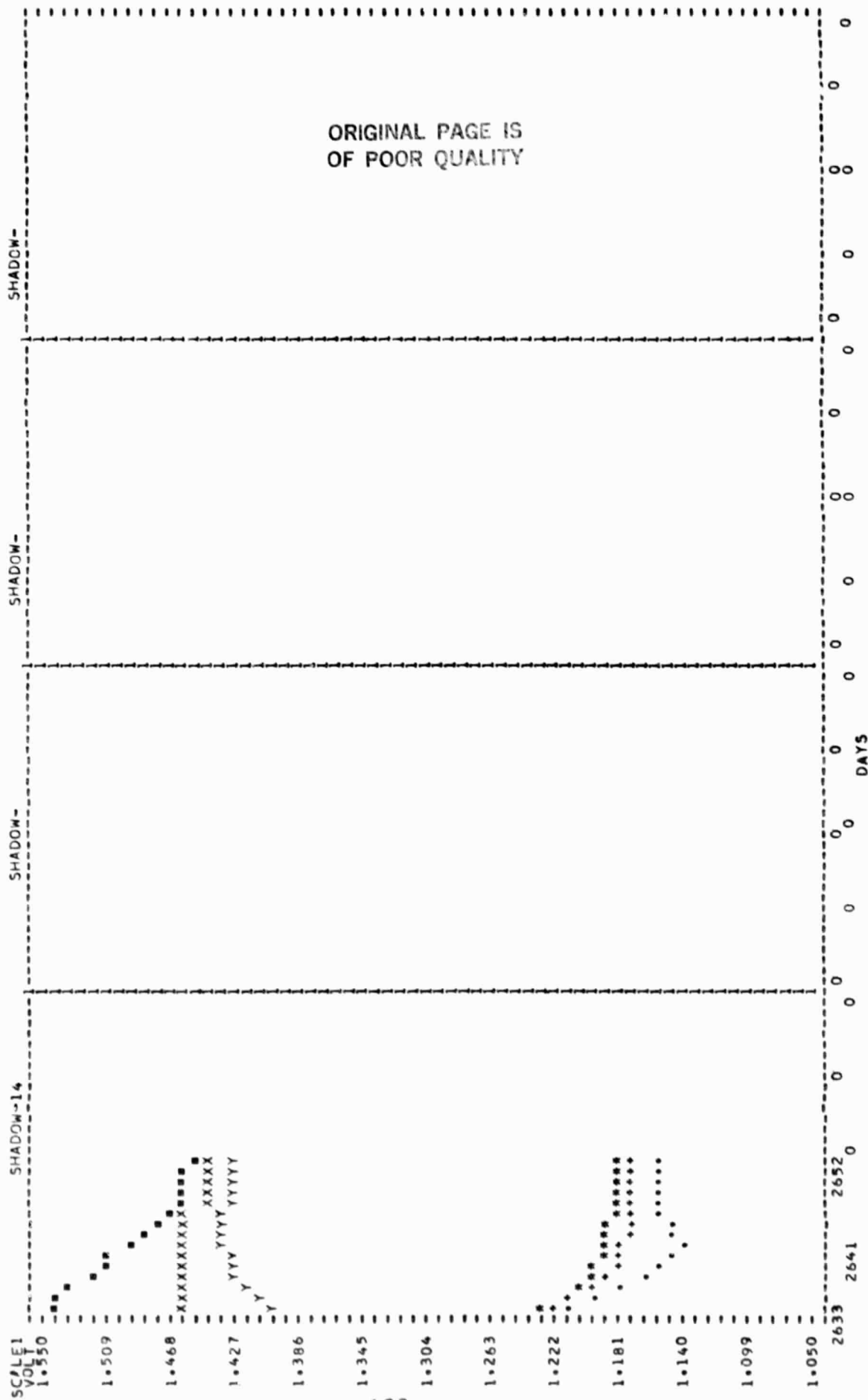


FIGURE 159

KEY
 * AHO
 * AHI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 10
 AMPLITUDE RATE 12
 MAGNETIC FIELD 15
 SERIAL 005 002 015 014 025

PACK = 222A

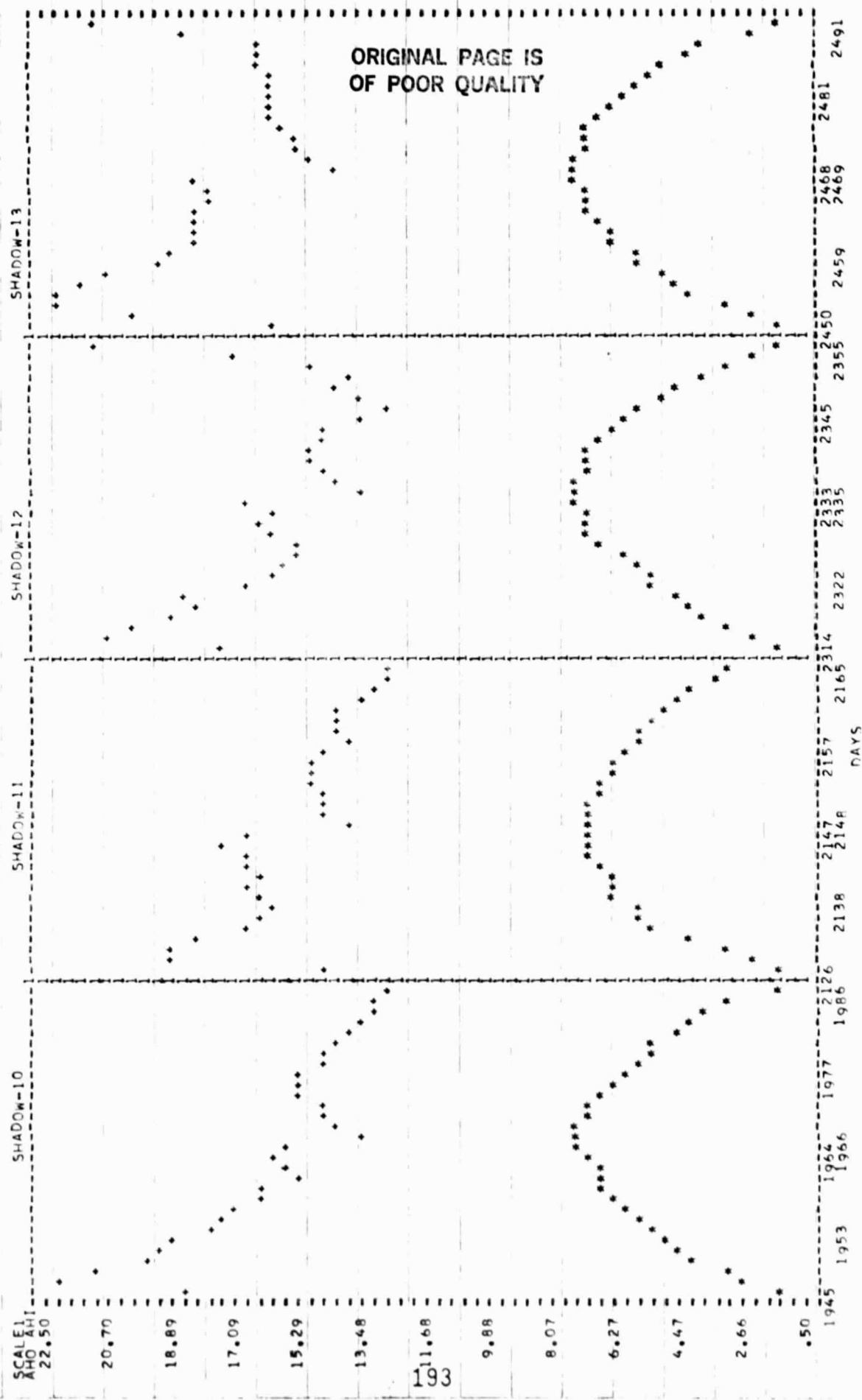


FIGURE 160

KEY
 * AHO
 + AHI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 222A

DEPTH DISCHARGE 60 WDEC/C 81-120A
 TEMPERATURE 10
 ALTITUDE RATE 12
 EASLE PITCHER CELLS
 SERIAL 005 002 015 014 025

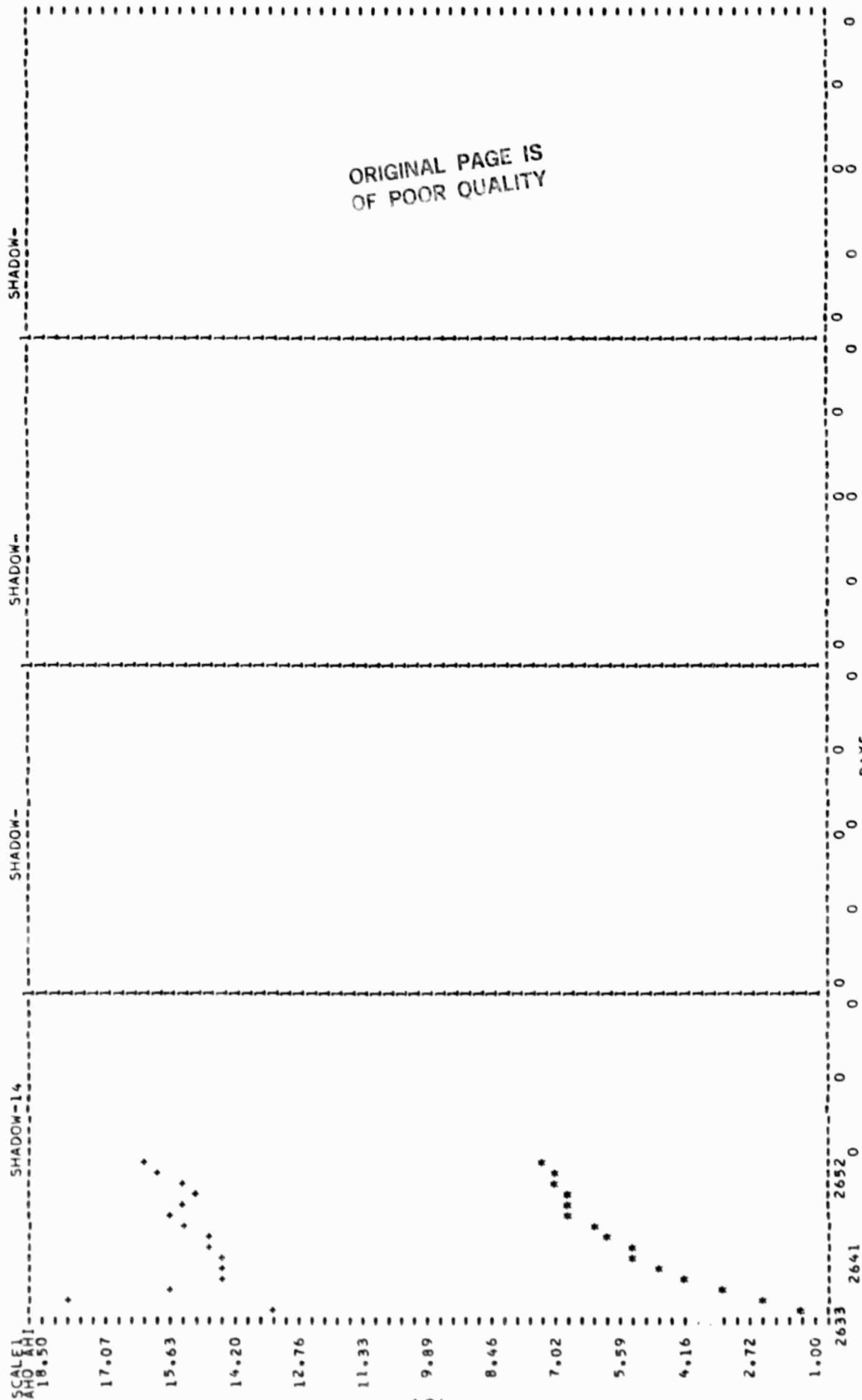


FIGURE 161

DEPTH DISCHARGE 60 WQEC/C 81-120A
 TEMPERATURE 10
 AMPERE RATE 12
 SERIAL 005 002 015 014 025

EAGLE PITCHER CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 222A

KEY
 * END CHARGE CURRENT

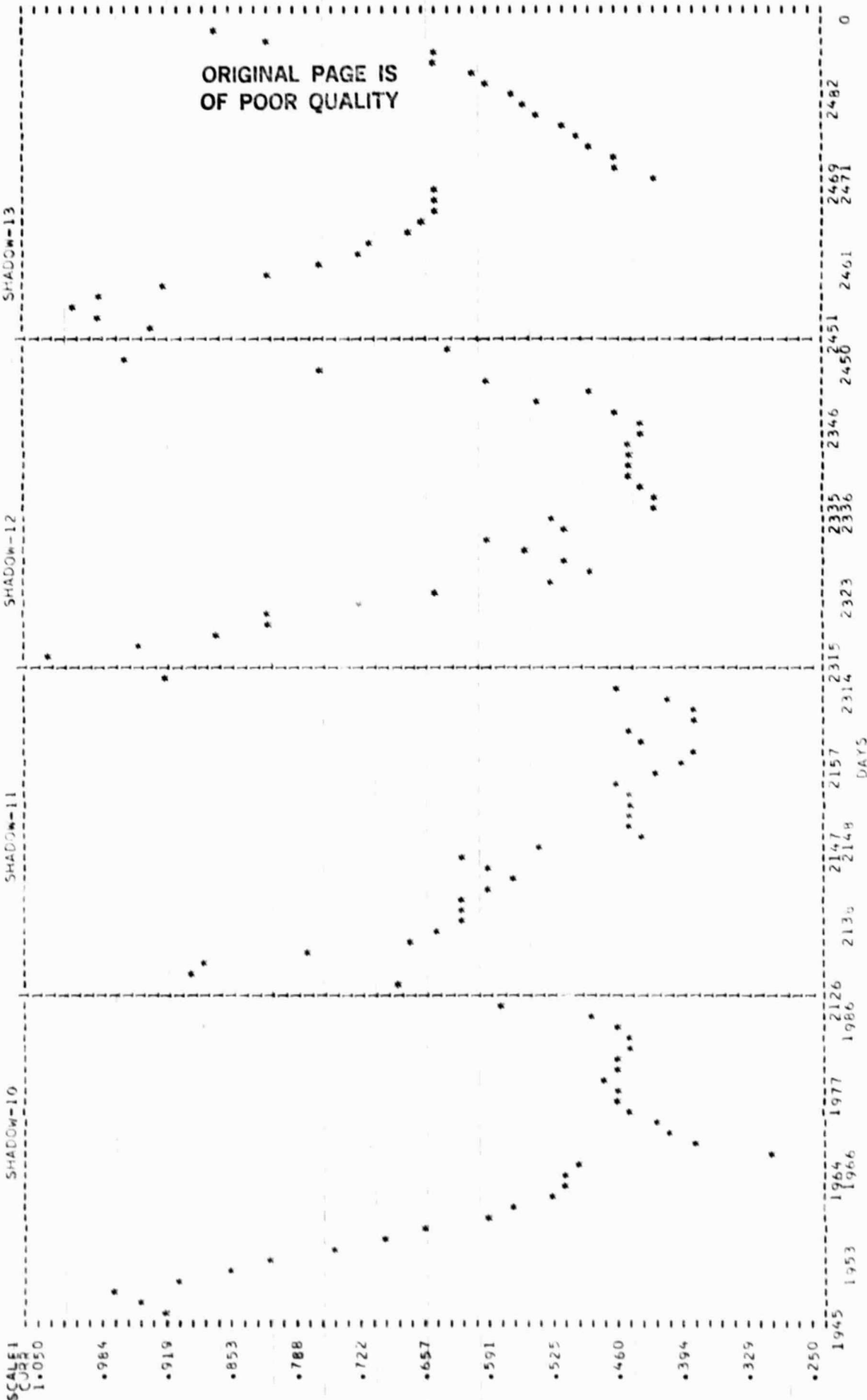


FIGURE 162

KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
TEMPERATURE 10
AMPERE RATE 12
SERIAL 005 002 015 014 025

EAGLE PITCHER CELLS

PACK = 222A

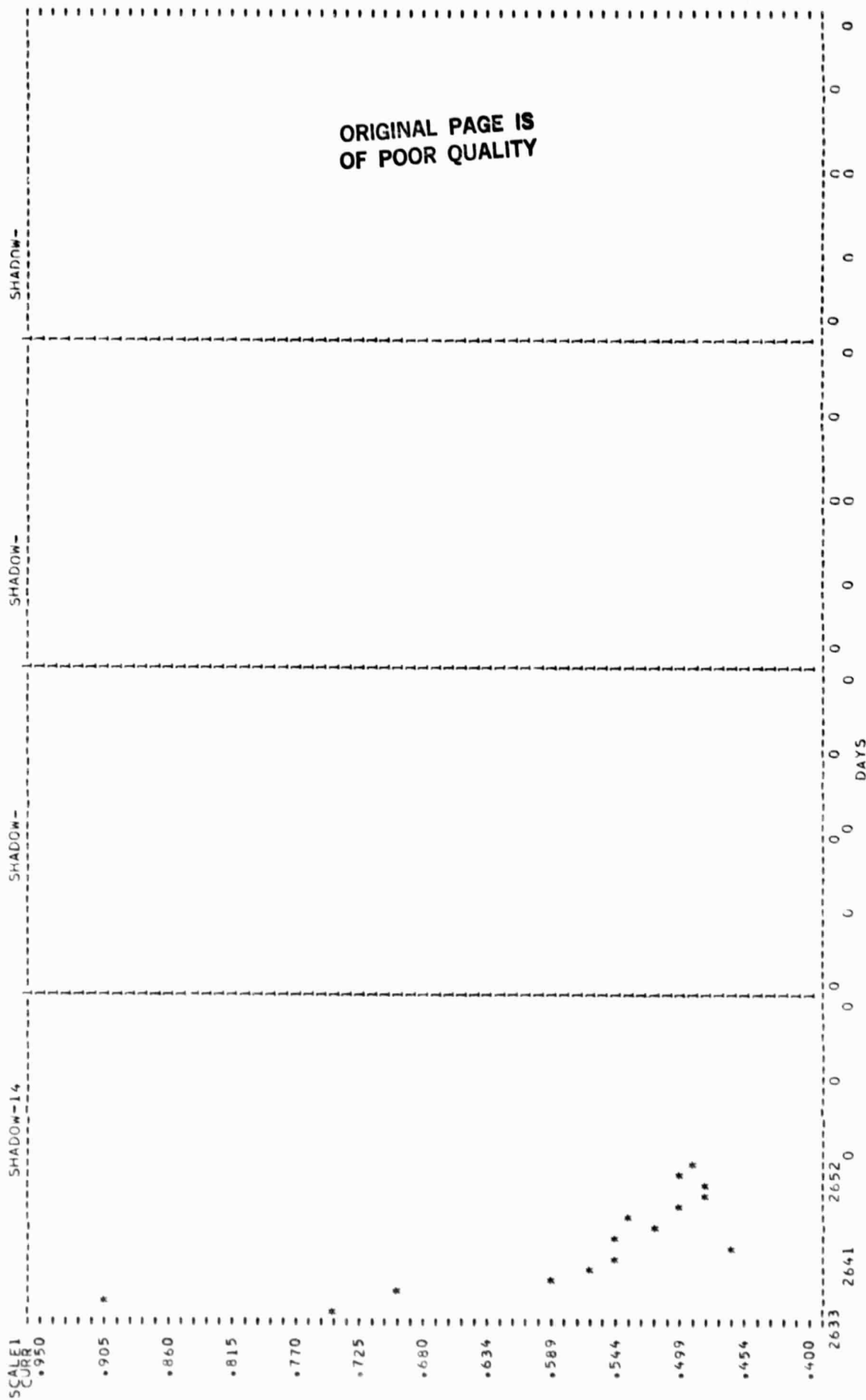


FIGURE 163

3. Pack 223A, 5-cells

a. Cell information: (Same as pack 221A, Section V.E.1.)

b. Parameters:

| | | | |
|--------------------------|-------|----------------------|-------|
| Depth of Discharge (%) | 60 | Temperature (°C) | 0 |
| Charge Control | VL | Float Voltage (v/c)* | 1.495 |
| Charge Current (amps) | 1.20 | Auxiliary Electrode: | |
| Discharge Current (amps) | 6.00 | Resistance (ohms) | 20 |
| Voltage Limit (v/c) | 1.495 | | |

*--Current reduced to .20 ampere during sun period 7 due to pack overcharging.

c. Capacity Checks: (Discharge to .50 volts any cell)

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell
5 | ah
out |
|------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Precycling | .500 | .770 | .934 | .803 | .680 | 15.80 |
| Shadow 1 | .918 | .869 | .911 | .793 | .466 | 16.25 |
| Shadow 2 | .849 | .942 | .931 | .647 | .513 | 16.82 |
| Shadow 3 | .880 | .827 | .886 | .528 | .489 | 16.69 |
| Shadow 4 | .437 | .769 | .800 | .388 | .353 | 17.08 |
| Shadow 5 | .495 | .815 | .808 | .538 | .501 | 17.46 |
| Shadow 6 | .457 | .753 | .768 | .578 | .461 | 17.88 |
| Shadow 7 | .570 | .858 | .909 | .666 | .624 | 17.13 |
| Shadow 8 | .623 | .842 | .838 | .793 | .467 | 16.59 |
| Shadow 9 | .629 | .874 | .842 | .832 | .485 | 16.97 |
| Shadow 10 (Figure 164) | .734 | .853 | .768 | .825 | .448 | 16.97 |
| Shadow 11 (Figure 165) | .465 | .603 | .741 | .721 | .490 | 16.20 |
| Shadow 12 (Figure 166) | .521 | .728 | .689 | .690 | .466 | 16.43 |
| Shadow 13 (Figure 167) | .389 | .600 | .649 | .501 | .437 | 17.20 |
| Shadow 14 (Figure 168) | 17.88 | 18.55 | 18.55 | 17.88 | 18.12 | |
| Post
Cycling (Figure 169) | 14.66 | 15.20 | 15.20 | 15.20 | 14.90 | |

d. Test results during the Shadow Periods: (Figures 170 to 175)

(1) End of Discharge Voltages: Effect of the reconditioning of the pack, due to the capacity check, can be seen for each shadow.

(2) End of Charge Voltages: The cells have been unbalanced, at the end of charge, throughout each shadow period. The unbalance was the greatest during the first half of each shadow except for shadow 11 when it was greatest during the second half.

(3) Ampere-Hour Input: Input was high at the beginning of shadows 6 and 7; but was lower for shadow 8. This was due to the pack being overcharged during float between shadows 7 and 8. Normally, input is greatest at the start of each shadow when cell divergence is greatest.

(4) Pressures at End of Charge: The pressures on cells 1 and 5 increased from 15 and 25 psia, during period 1, to a maximum of 55 and 85 psia during shadow 7. The pressures were less for shadow 8 and 9 in which the maximum (cell 5) was 55 psia for shadow 8 and 30 psia for shadow 9. These lower pressures followed the pack being placed on a trickle charge during its' sun periods. Maximum pressures were during the second half of the shadows as the pressures would increase during the charge portion of the capacity checks. Maximum pressures were during shadow 13's capacity check in which the pressures of cells 1 and 5 increased from 40 and 38 psia, to 77 and 115 psia respectively.

(5) The pack was discontinued in the middle of shadow 14 in which each cell was discharged to .50 volts.

(6) Capacity Checks and Post Cycling: When the pack was discontinued, its capacity averaged 18.20 ah and 17 percent of this was below the 1.00 volt level. This percentage is approximately double that obtained during precycling (7 percent) and shadow 1 (9 percent). The average post cycling capacity was 15.03 ah following a 1.20 ampere charge for 24 hours at 0°C with a voltage limit of 1.495 v/c.

(7) Cell 2 was sent to EP and the remaining cells were disposed of.

e. Performance during Sun Periods: The pack completed 13 sun periods as it began test with a shadow period. The pack floated at its voltage limit for the first 6 periods then was placed on a trickle charge of .2 amperes during the seventh period because of increased cell temperature. The pack was then placed on its voltage limit with a maximum current of .2 amperes. Pressures had increased from a maximum of 25 psia to 75 psia during periods 1 to 6, then decreased to less than 15 psia during periods 7 through 13. Cell 5 exhibited the highest pressure throughout the sun periods. Following is a listing of the high, average and low cell voltages and current (amps) at the start and end of each sun period.

Sun Periods

| | | 1 | | 2 | | 3 | | 4 | |
|------------|--|----------|----------|----------|----------|----------|------------|----------|----------|
| Voltages** | | Start | End | Start | End | Start | End | Start | End |
| High | | 1.519(1) | 1.517(4) | 1.530(1) | 1.515(4) | 1.510(1) | 1.518(4) | 1.512(3) | 1.558(5) |
| Average | | 1.496 | 1.495 | 1.493 | 1.495 | 1.497 | 1.495 | 1.497 | 1.497 |
| Low | | 1.450(2) | 1.476(2) | 1.476(2) | 1.484(2) | 1.481(2) | 1.482(2) | 1.478(1) | 1.428(1) |
| Current | | .13 | .07 | .18 | .06 | .04 | .05 | .09 | .17 |
| | | 5 | | 6 | | 7*** | | 8 | |
| Voltages | | Start | End | Start | End | Start | End | Start | End |
| High | | 1.532(1) | 1.529(4) | 1.519(4) | 1.534(5) | 1.515(4) | 1.441(5) | 1.534(4) | 1.432(5) |
| Average | | 1.495 | 1.494 | 1.495 | 1.496 | 1.493 | 1.434 | 1.494 | 1.425 |
| Low | | 1.410(3) | 1.459(1) | 1.439(3) | 1.470(1) | 1.454(3) | 1.425(1) | 1.439(3) | 1.415(1) |
| Current | | .08 | .70 | .17 | .70 | .23 | .20 | .15 | .20 |
| | | 9 | | 10 | | 11 | | 12 | |
| Voltages | | Start | End | Start | End | Start | End | Start | End |
| High | | 1.525(4) | 1.447(3) | 1.522(4) | 1.435(5) | 1.510(5) | 1.430(3) | 1.512(2) | 1.444(3) |
| Average | | 1.496 | 1.426 | 1.496 | 1.427 | 1.495 | 1.410 | 1.494 | 1.421 |
| Low | | 1.443(3) | 1.417(1) | 1.449(3) | 1.410(4) | 1.480(3) | 1.401(1,4) | 1.451(3) | 1.412(1) |
| Current | | .2 | .2 | .2 | .2 | .18 | .2 | .2 | .2 |
| | | 13 | | | | | | | |
| Voltages | | Start | End | | | | | | |
| High | | 1.494(5) | 1.440(2) | | | | | | |
| Average | | 1.470 | 1.434 | | | | | | |
| Low | | 1.440(3) | 1.425(1) | | | | | | |
| Current | | .2 | .2 | | | | | | |

**--() indicates which cell

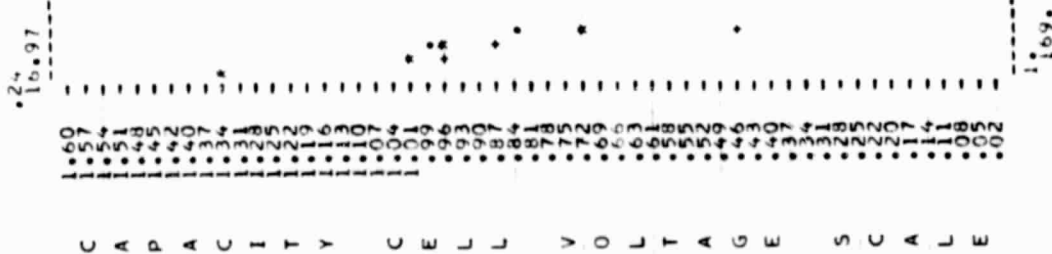
***--current reduced to .2 amperes during this period

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PACK NUMBER IS 223A
SHEDDING PERIOD IS 10
CYCLE NUMBER IS 1965
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE



TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 164

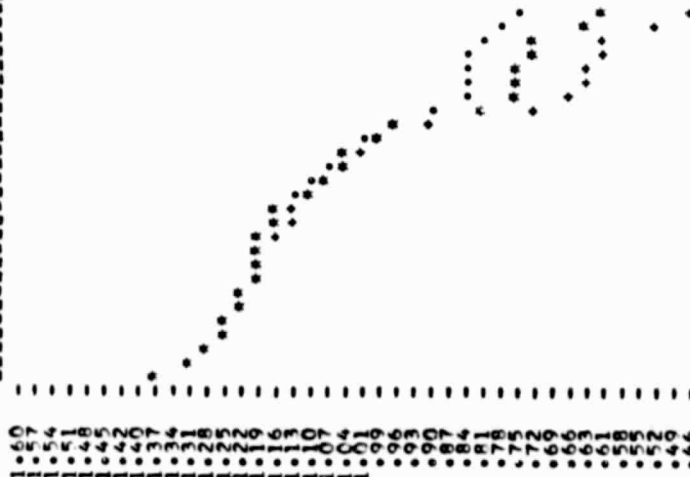
PACK NUMBER IS 223A
 SHADOW PERIOD IS 11
 CYCLE NUMBER IS 2146.
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KFY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

24 5.93 10.69 14.31 15.94 16.19
 2.92 8.75 13.06 15.46

C
A
P
A
C
I
T
Y
C
E
L
L
V
O
L
T
A
G
E
S
C
A
L
E



1.28 57.86 106.130.148.154. 158. 161.

TIME IN MINUTES
 CELLS INCLUDED V1 V2 V3 V4 V5

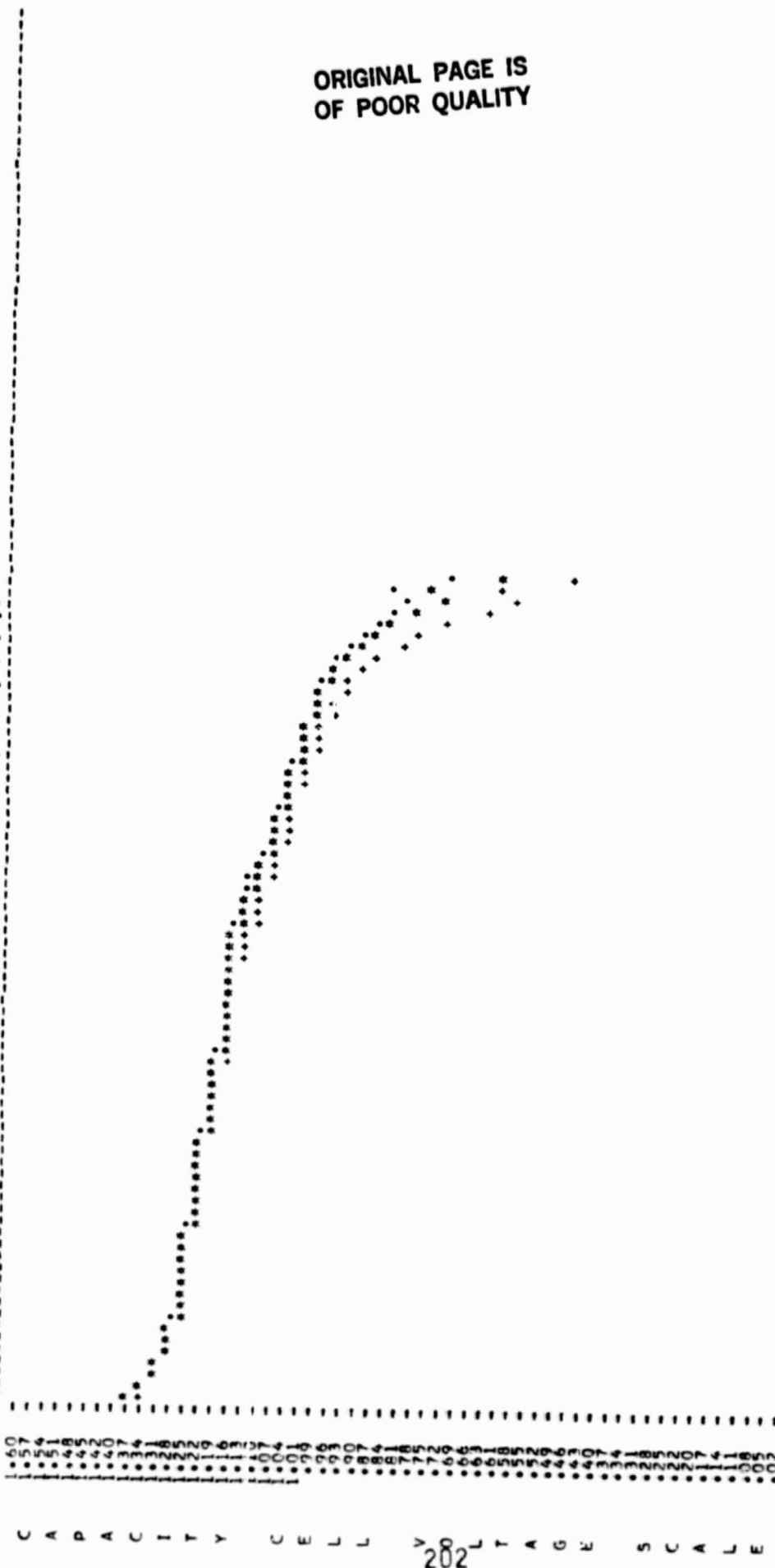
FIGURE 165

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PACK NUMBER IS 223A
 SHADOW PERIOD IS 12
 CYCLE NUMBER IS 2334.
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

24. 1.72 3.19 4.66 6.13 7.60 9.07 10.54 12.02 13.49 14.96 16.43
 .98 2.45 3.92 5.39 6.86 8.33 9.80 11.26 12.73 14.20 15.67 17.14



TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 166

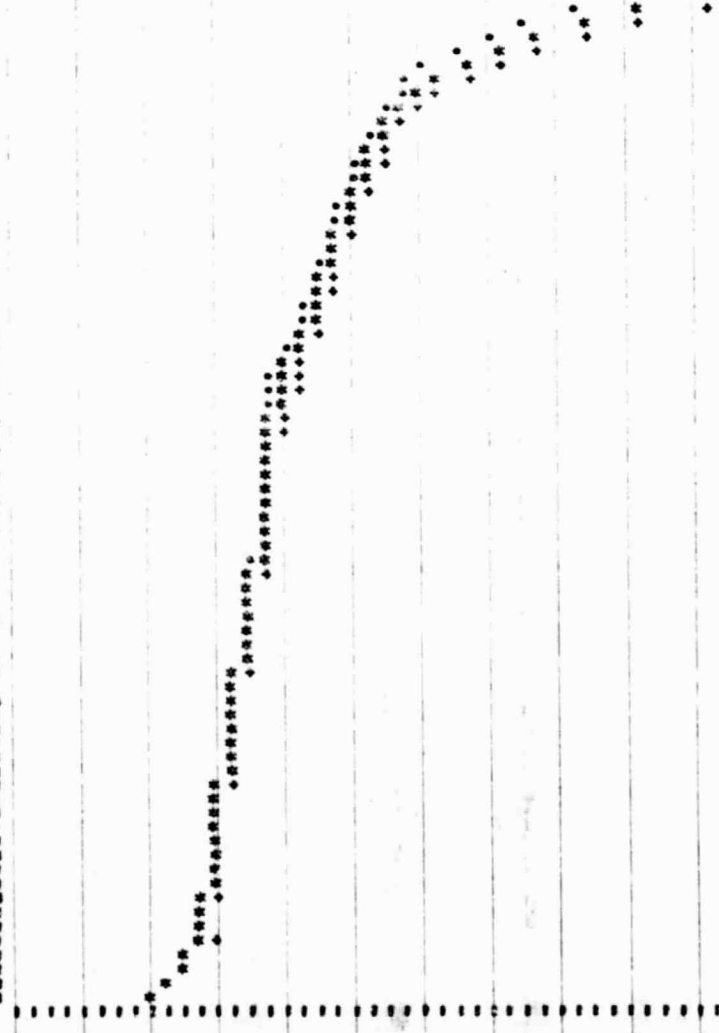
KEY
 : HIGH CELL
 : LOW CELL
 : AVERAGE

PACK NUMBER IS 223A
 SHADOW PERIOD IS 13
 CYCLE NUMBER IS 02470
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

2. 1.68 3.11 4.52 5.99 7.42 8.86 10.29 11.96 13.40 14.83 16.25 17.20
 .95 2.39 3.83 5.27 6.70 8.14 9.57 11.01 12.68 14.11 15.54 16.96

C A P A C I T Y C E L L V D 203 A G E S C A L E



1. 9. 16. 30. 45. 59. 73. 88. 102 109. 119. 133. 148. 162. 172.
 .95 2.39 3.83 5.27 6.70 8.14 9.57 11.01 12.68 14.11 15.54 16.96

CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 167

ORIGINAL PAGE IS
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ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER 15 223A
POST CYCLING
CYCLE NUMBER 15 2654
DISCHARGE RATE 15 6.0

AMPERE HOUR OUT

12 1.54 2.97 4.39 5.82 7.27 8.71 10.14 11.56 12.99 14.42 15.20
.83 2.25 3.68 5.10 6.55 7.99 9.42 10.85 12.28 13.71 14.90

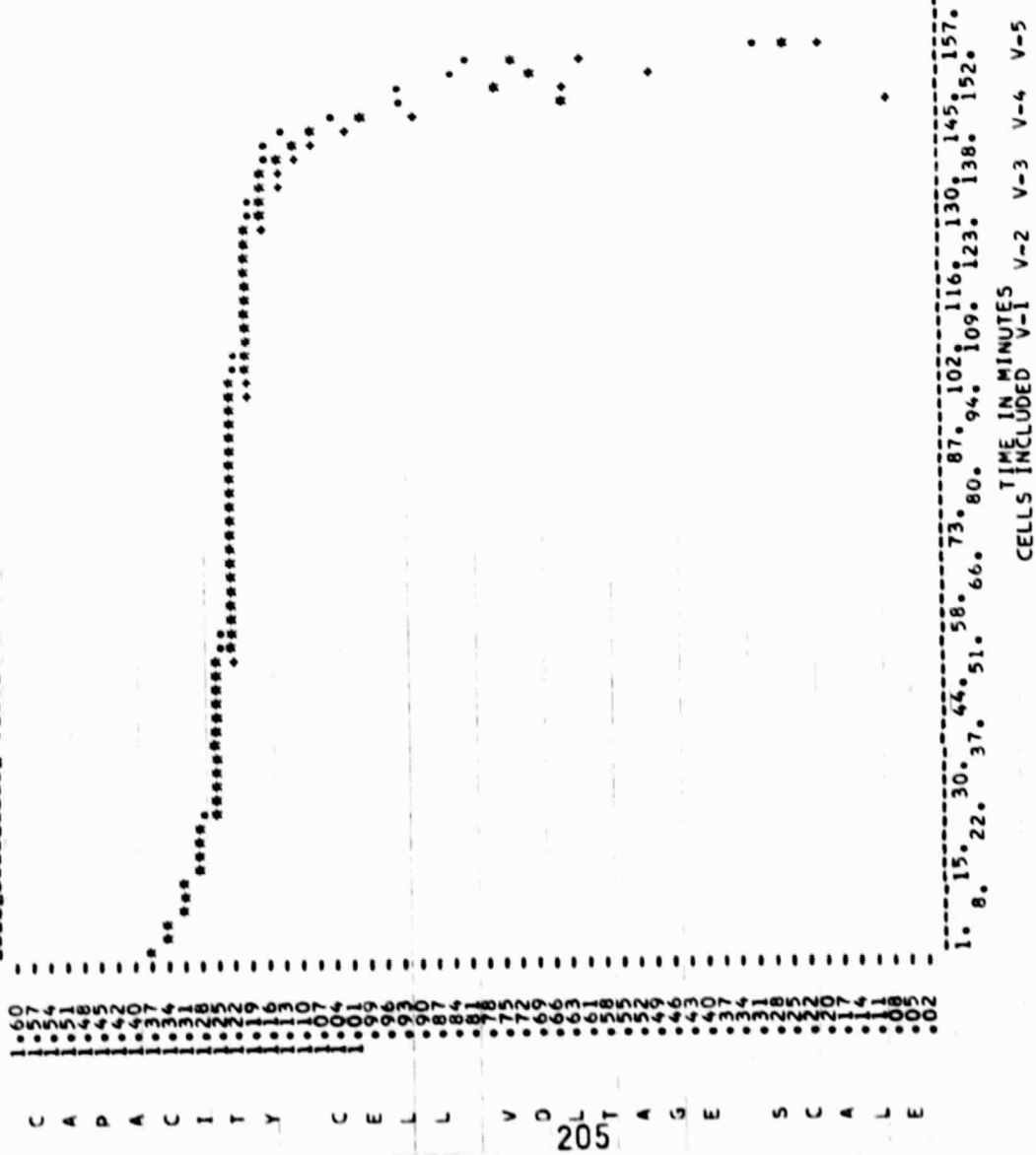


FIGURE 169

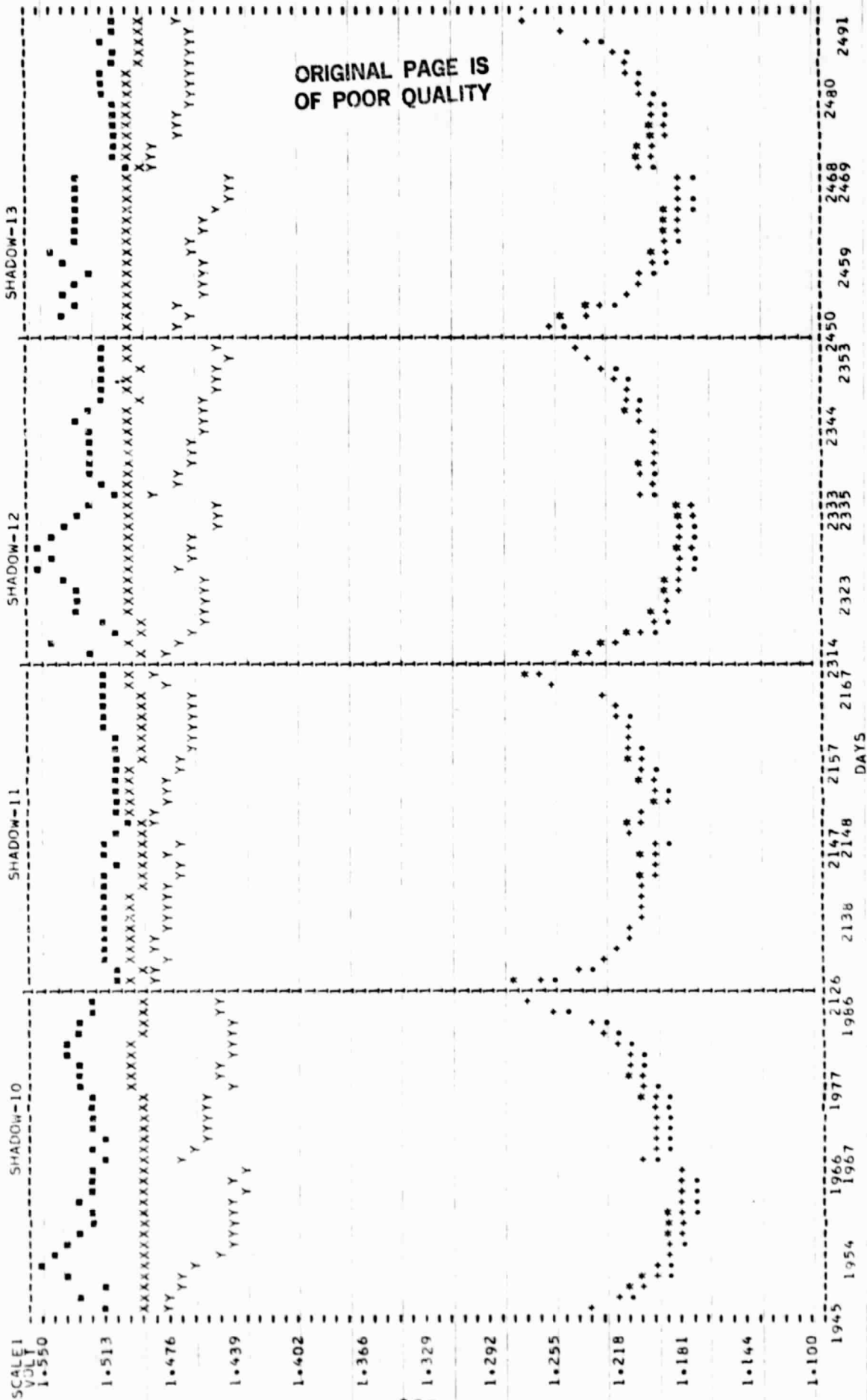
DEPTH DISCHARGE 60
TEMPERATURE 00
AMPLITUDE 12
EAGLE PITCHER CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
* HIGH
+ AVE
• LOW
• HIGH EOC
X AVE EOC
Y LOW EOC

SERIAL 003 020 016 024 021

PACK = 223A

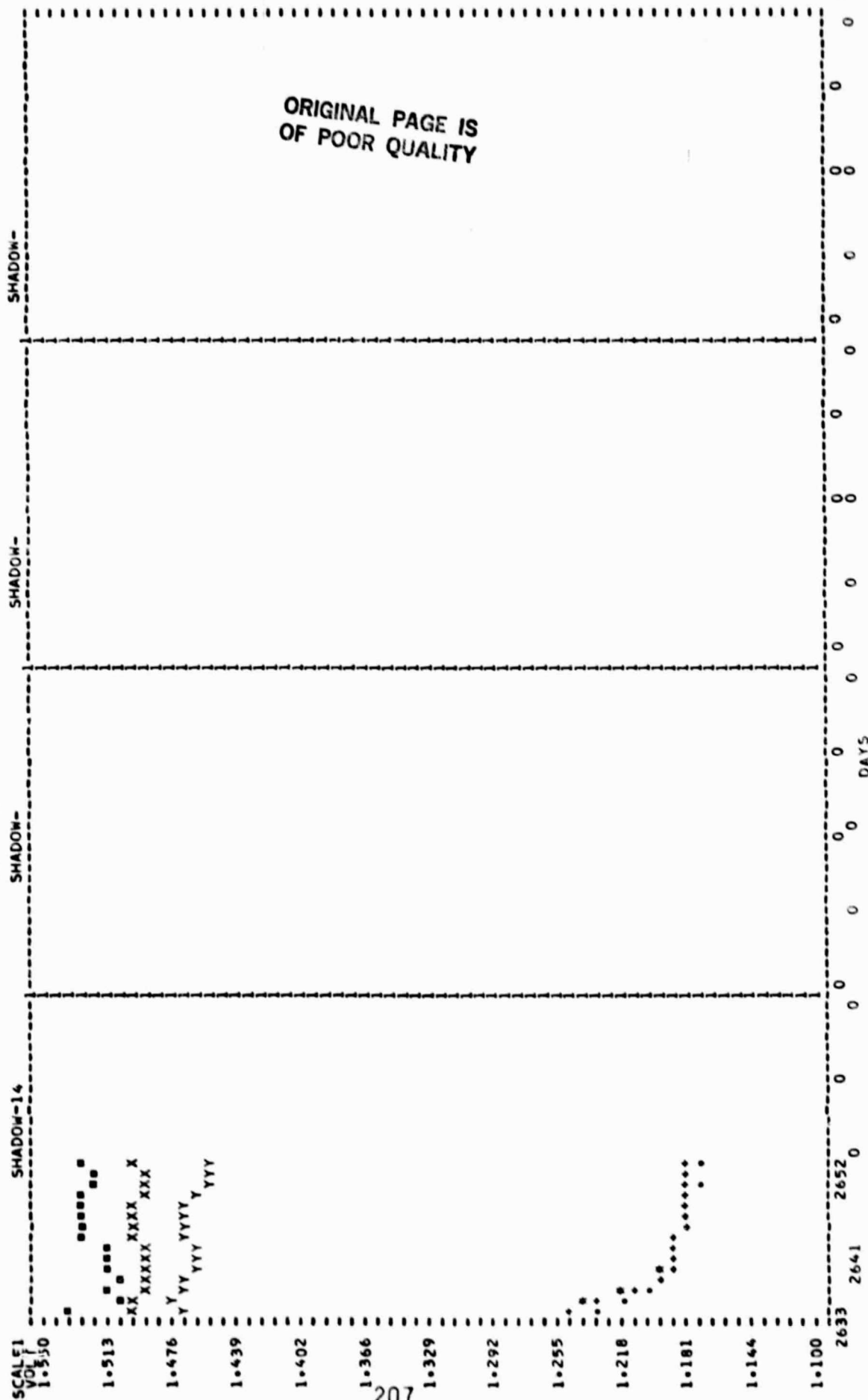


SERIAL 003 020 016 024 021

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 223A

| KEY | DISCHARGE VOLTAGE | DISCHARGE VOLTAGE | DISCHARGE VOLTAGE |
|--------|-------------------|-------------------|-------------------|
| • HIGH | END | END | END |
| • AVE | END | END | END |
| • LOW | END | END | END |
| • HIGH | EOC | EOC | EOC |
| • AVE | EOC | EOC | EOC |
| • LOW | EOC | EOC | EOC |



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KEY
* AHO
+ AHI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
TEMPERATURE 00
AMPERE RATE 12
EAGLE PITCHER CELLS
SERIAL 003 020 016 024 021

PACK = 223A

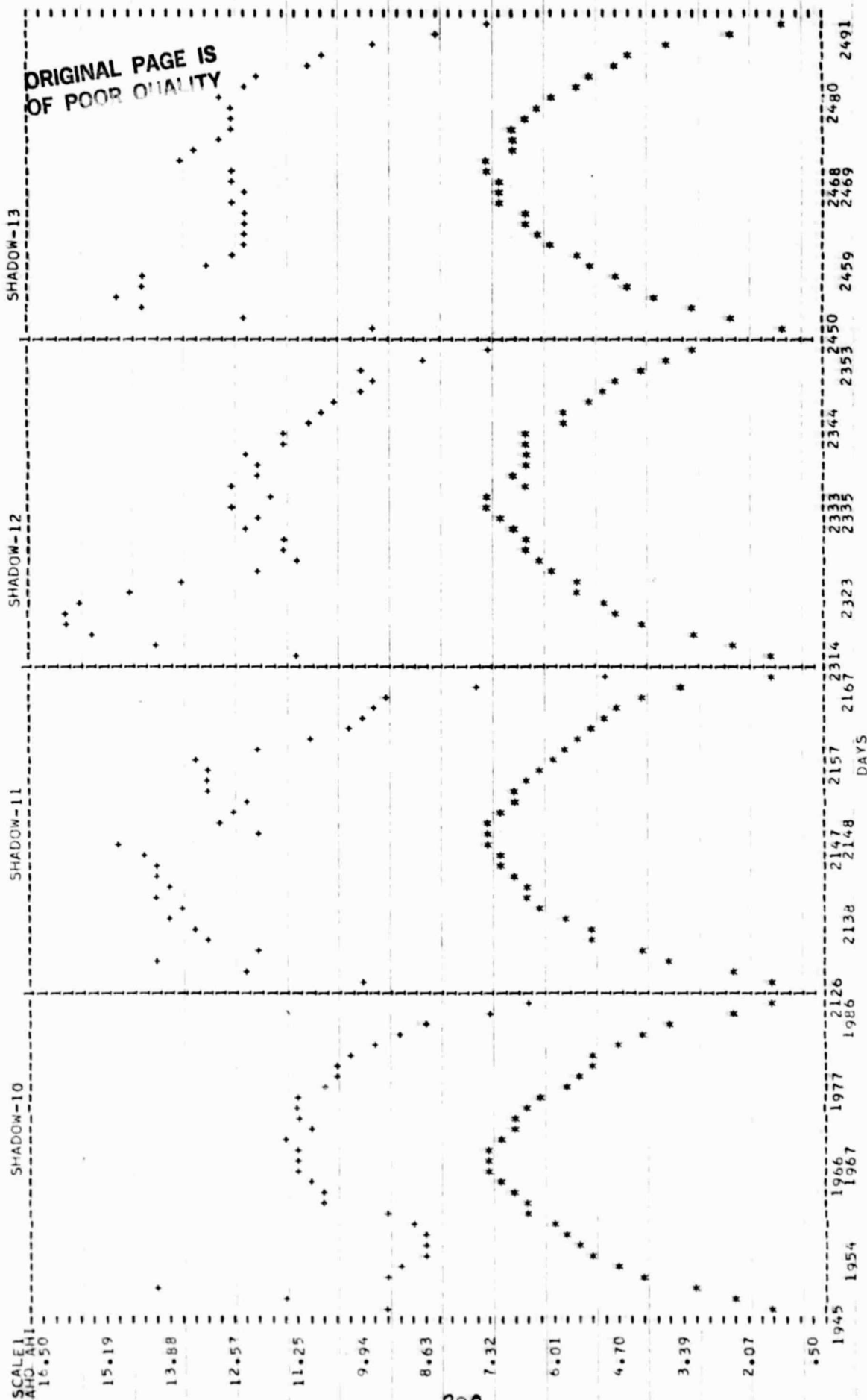


FIGURE 172

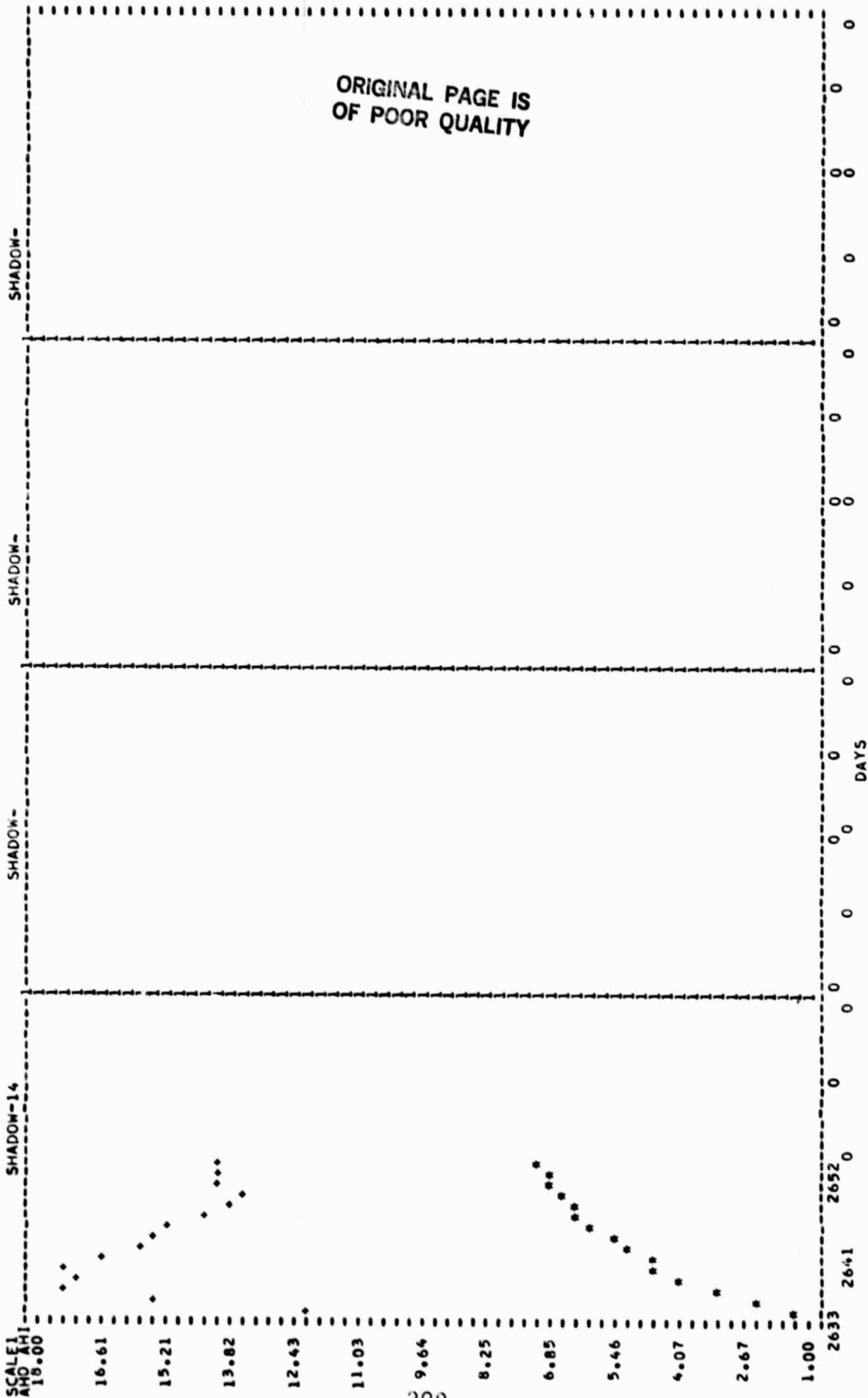
KEY
 * AHO
 * AH-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 00
 AMPERE RATE 12
 EAGLE PITCHER CELLS
 SERIAL 003 020 016 024 021

WQEC/C 81-120A

PACK = 223A



ORIGINAL PAGE IS
 OF POOR QUALITY

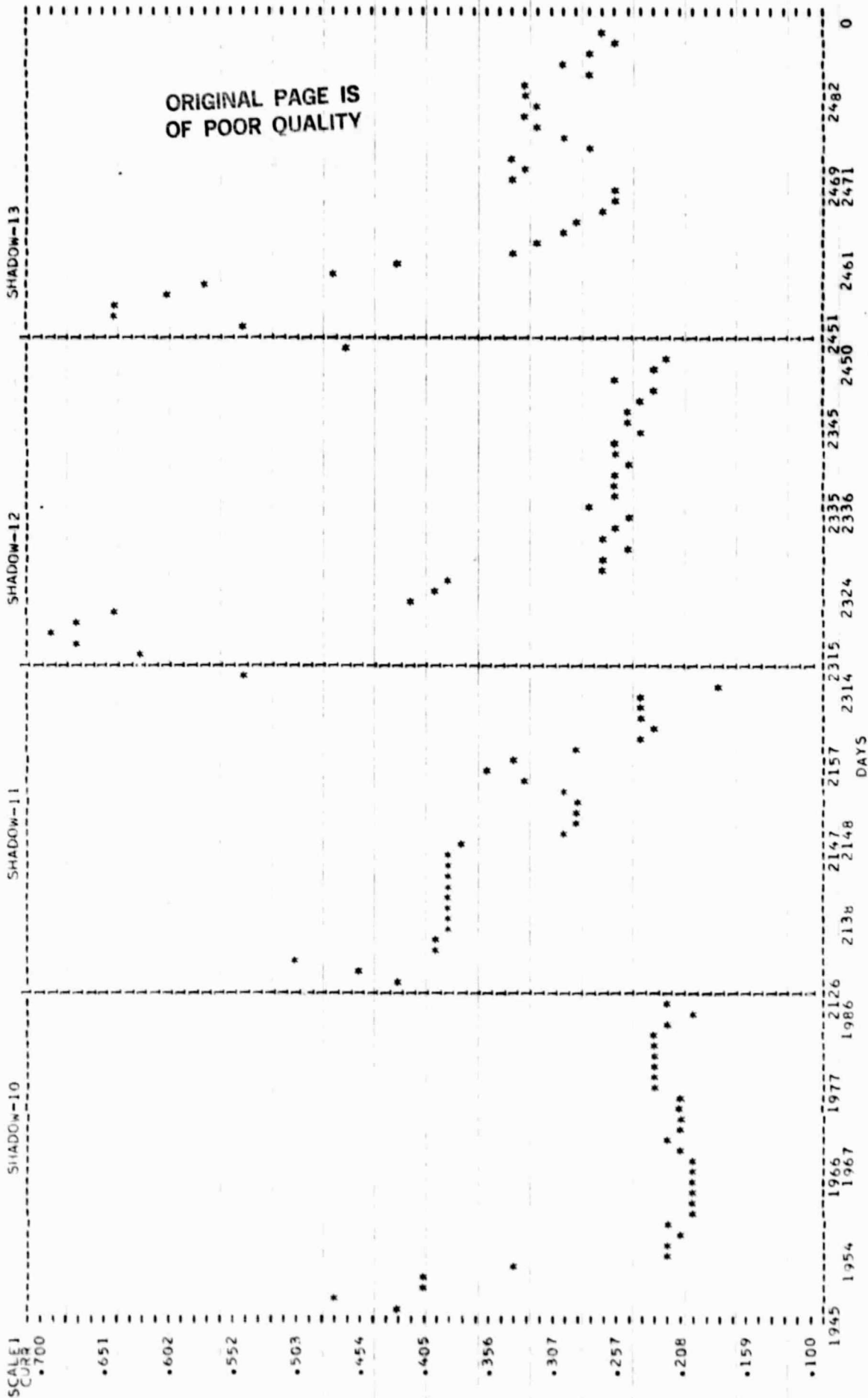
KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WDEC/C 81-120A
TEMPERATURE 00
AMPERE RATE 12
SERIAL 003 020 016 024 021

EAGLE PITCHER CELLS

PACK = 223A



F. GE 12.0 ah (Prototype-ATS F & G)

1. Pack 207A, 5-cells

a. Cell information:

(1) The cells were purchased, and provided for test, by NASA, GSFC for the purpose of gathering performance information concerning sealed nickel-cadmium cells with auxiliary electrodes in synchronous orbit. The cells were placed on test to demonstrate the feasibility of using this type of cell design for the ATS F & G satellite in synchronous orbit. These cells began test on 22 March 1969. The cells were identified with the manufacturers catalog numbers 42B012AB09 (auxiliary electrode type) and 42B012AB10. Acceptance test results and detailed cell descriptions are contained in the NAD Crane QE/C 69-553 of 15 July 1969. The results of the first four eclipse seasons were reported in the NAD Crane Report QE/C 71-183 of 10 June 1971 and seasons 5 through 14 were reported in Crane Report WQEC/C 77-134 of 9 June 1977. Cell 1, in each pack, was fitted with a pressure transducer prior to testing.

(2) One uncycled cell was sent to GSFC for analysis and the results were presented in the 9 June 1977 report.

b. Parameters:

| | | | |
|--------------------------|-----|-------------------------------|-----|
| Depth of Discharge (%) | 60 | Float/Trickle Current (amps)* | .15 |
| Charge Control | AE | Auxiliary Electrode** | |
| Charge Current (amps) | 1.5 | Resistance (ohms) | 300 |
| Discharge Current (amps) | 6.0 | Trip Voltage (mv) | 150 |
| Temperature (°C) | 0 | | |

*--Reduced to .15 amps, from .20 amps, during sun period 10.

**--Cells 1, 4 and 5.

c. Capacity checks: (Discharge to .50 volts any cell)

| | Cell
1 | Cell
2 | Cell
3 | Cell***
4 | Cell***
5 | ah
out |
|---------------------------|-----------|-----------|-----------|--------------|--------------|-----------|
| Shadow 5 | .579 | .951 | .853 | .670 | .497 | 16.72 |
| Shadow 6 | .691 | .919 | .877 | .493 | .561 | 16.64 |
| Shadow 7 | .905 | .942 | .940 | .435 | .439 | 16.20 |
| Shadow 8 | .914 | .959 | .965 | .580 | .540 | 16.31 |
| Shadow 9 | -.20 | 1.160 | 1.164 | 1.100 | 1.110 | 11.43 |
| Shadow 10 | .207 | 1.176 | 1.177 | 1.160 | 1.162 | 4.13 |
| Shadow 11 | *** | .842 | .770 | .557 | .441 | 15.62 |
| Shadow 12 | | .960 | .947 | .540 | .411 | 14.39 |
| Shadow 13 | | .952 | .885 | .465 | .390 | 14.39 |
| Shadow 14 | | .981 | .948 | .468 | .410 | 13.18 |
| Shadow 15 (Figure 176) | | .993 | .971 | .553 | .426 | 12.46 |
| Shadow 16 (Figure 177) | | 1.003 | .982 | .480 | .331 | 11.96 |
| Shadow 17 (Figure 178) | | 1.009 | .992 | .630 | .492 | 11.45 |
| Shadow 18 (Figure 179) | | 1.104 | 1.099 | .977 | .459 | 9.03 |
| Shadow 19 (Figure 180) | | 1.162 | 1.163 | .441 | .496 | 7.38 |
| Shadow 20 (Figure 181) | | .599 | .447 | 4.41 | 4.16 | 10.16 |
| Shadow 21 (Figure 182) | | .601 | .407 | 6.85 | 7.28 | 12.79 |
| Shadow 22 (Figure 183) | | .573 | .341 | 6.73 | 7.28 | 12.24 |
| Shadow 23 (Figure 184) | | 12.68 | 12.19 | 7.41 | 7.41 | |
| Post Cycling (Figure 185) | | 10.34 | 11.32 | 8.26 | 8.26 | |

***--Cell 1 leaking, removed prior to shadow 11; low discharge voltage failure: Cell 5 (day 3461, shadow 19) and cell 4 (day 3635, shadow 20); but cells allowed to continue cycling.

d. Test results during the Shadow Periods: (Figures 186 to 191)

(1) Cells 4 and 5 failed (below .50 volts during discharge) during shadows 20 and 19, respectively. The cells were allowed to continue cycling and they did experience cell reversal; but did not short. The pressure transducer assembly on cell 1 was bumped during its sun period prior to shadow 9, which caused the weld at the base of the fill tube to break. This resulted in the cell "drying out" and it was removed from test prior to shadow 11.

(2) Average End of Discharge Voltages: The reconditioning effect, due to the capacity checks, were evident as the average voltage increased during the second half of each shadow period. The increase in the effect during shadow 20 was the result of cells 2 and 3 being discharged to a lower value during the capacity check than they were during the capacity check of shadow 19. The auxiliary electrode EOD voltages of cells 4 and 5 were -.472 and -.588 volts, respectively, on day 3637 as both cells were reversed (below -.150 volts) at this time.

(3) Average Cell Voltage at Trip and End of Charge: The averages at trip were lower than those at the end of charge, prior to period 11. During period 11, and the following periods, this was completely reversed. Also, the trip and end of charge voltages increased each successive period until shadow 15. The trickle charge current was reduced from .2 to .15 ampere during shadow 11 in an effort to reduce the end-of-charge voltages. The trip voltages at the beginning of each shadow period are high, due to the auxiliary electrodes, during the sun periods, appearing to become "desensitized" to the oxygen produced during charge. The electrodes became "sensitized" again after 2 to 7 days into the period for the first 10 shadows. Beginning with shadow 11, the cells only generated sufficient oxygen to provide a trip signal when the cell voltages were above 1.60 volts. During the period that the auxiliary electrodes were not functioning properly, the cells were placed on trickle charge when any cell's voltage reached 1.70 volts on the high charge rate.

(4) The pack was discontinued in the middle of shadow 23 in which each cell was discharged to .50 volts.

(5) Post Cycling: Capacities ranged from 8.26 to 11.32 ampere-hours following a 1.50 ampere charge to an auxiliary electrode voltage of 150 millivolts at 0°C.

e. Performance during Sun Periods: The pack began test with a shadow period and therefore completed 22 sun periods. Pressures, cell 1, were less than 12 psia prior to period 8 when its pressure assembly began leaking. The trickle current was reduced from .20 to .15 amperes, during period 10, in an effort to reduce the high cell voltages. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 15 through 22.

SUN PERIODS

| | 15 | | | 16 | | | 17 | | | 18 | | |
|---------|--------------|----------|----------|--------------|----------|----------|--------------|----------|-----|--------------|-------|-----|
| | Voltages**** | Start | End | Voltages**** | Start | End | Voltages**** | Start | End | Voltages**** | Start | End |
| High | 1.625(4) | 1.634(4) | 1.613(4) | 1.650(4) | 1.628(3) | 1.636(4) | 1.623(3) | 1.605(4) | | | | |
| Average | 1.619 | 1.528 | 1.598 | 1.527 | 1.614 | 1.547 | 1.596 | 1.525 | | | | |
| Low | 1.611(5) | 1.425(2) | 1.589(5) | 1.399(2) | 1.591(5) | 1.434(2) | 1.556(5) | 1.415(2) | | | | |

| | 19 | | | 20 | | | 21 | | | 22 | | |
|---------|--------------|----------|----------|--------------|----------|----------|--------------|----------|-----|--------------|-------|-----|
| | Voltages**** | Start | End | Voltages**** | Start | End | Voltages**** | Start | End | Voltages**** | Start | End |
| High | 1.629(3) | 1.588(4) | 1.549(4) | 1.518(4,5) | 1.629(2) | 1.535(5) | 1.624(3) | 1.551(5) | | | | |
| Average | 1.581 | 1.501 | 1.505 | 1.477 | 1.585 | 1.483 | 1.575 | 1.488 | | | | |
| Low | 1.533(5) | 1.406(2) | 1.454(2) | 1.409(2) | 1.534(4) | 1.410(2) | 1.525(4) | 1.415(2) | | | | |

****--() indicates which cell.

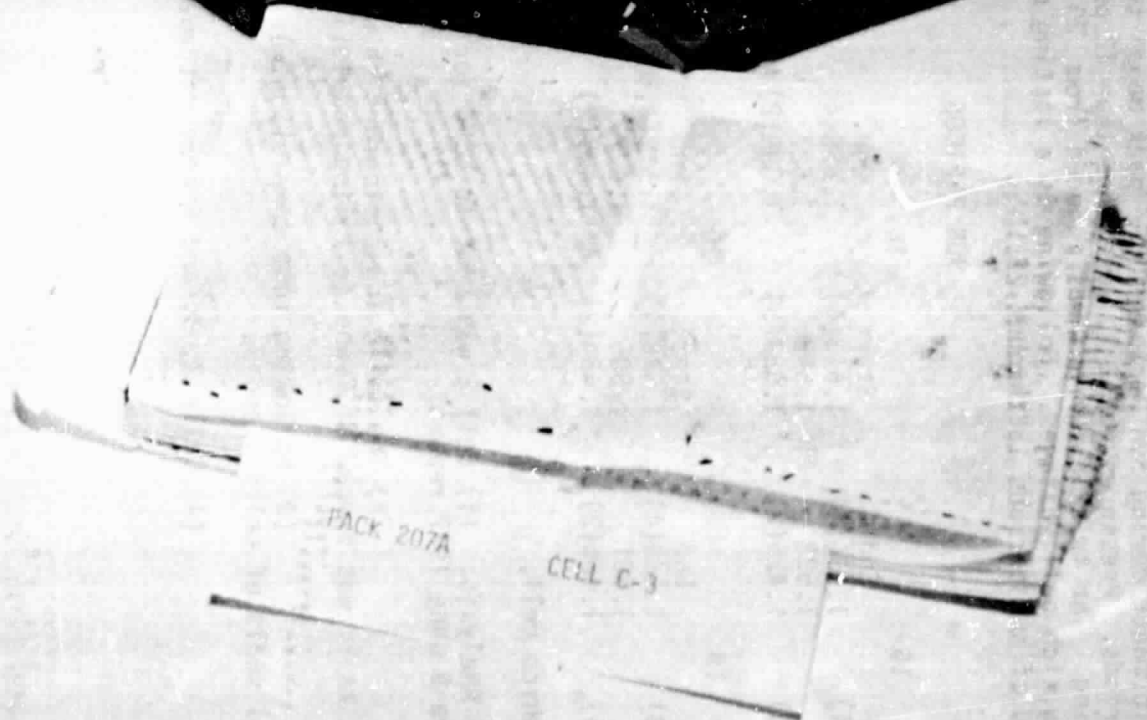
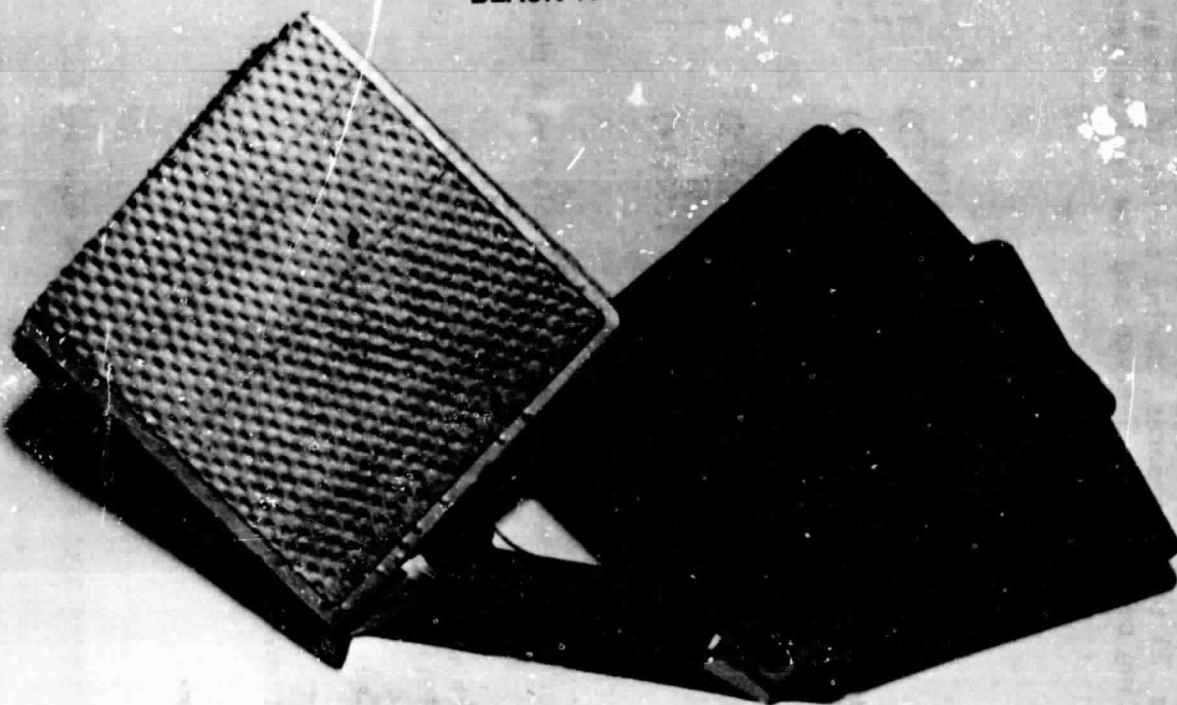
f. Cell Analysis: (1) Cell 1 was sent to GSFC for analysis and the results, including a photograph, were contained in the 9 June 1977 report.

(2) The following photograph shows the condition of the plates and separator of cell 3, as it was opened at Crane following completion of 22.5 shadow periods.

(3) Following test completion, leaks were found around the positive and negative terminal seals of cells 2 and 3.

(4) Cells 2, 4, and 5 were returned to GSFC.

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BLACK AND WHITE PHOTOGRAPH



Pack 207A, Cell 3, 22.5 shadow periods
at 60 percent DOD, 0°C: Cell was
moist and loose active material located
at bottom of uncoined positive plates.

PHOTOGRAPH 1
216

PACK NUMBER IS 207A
SHADOW PERIOD IS 16
CYCLE NUMBER IS 2957
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

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KEY HIGH CELL
* LOW CELL
* AVERAGE

24 1.71 3.17 4.61 6.10 7.56 9.03 10.49 11.96
.98 2.44 3.90 5.37 6.83 8.30 9.76 11.22

C A P A C I T Y C E L L V O L T A G E S C A L E

60 57 54 51 48 45 42 40 37 34 31 28 25 22 19 16 13 10 07 04 01 99 96 93 90 87 84 81 78 75 72 69 66 63 60 57 54 51 48 45 42 39 36 33 30 27 24 21 18 15 12 09 06 03 00

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102. 117.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4

FIGURE 177

PACK NUMBER IS 207A
SHADOW PERIOD IS 18
CYCLE NUMBER IS 032A1
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KEY HIGH CELL
• LOW CELL
• AVERAGE

24.98 1.71 2.42 3.17 4.64 5.37 6.10 7.57 8.03
6.83 8.30

C A P A C I T Y C E L L V O L T A G E S C A L E

67 57 55 51 48 45 42 40 37 34 32 30 28 25 22 19 16 13 10 07 04 01 99 96 93 90 87 84 81 78 75 72 69 66 63 61 58 55 52 49 46 43 40 37 34 31 28 25 22 19 16 13 10 07 04 01

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OF POOR QUALITY

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 87.

TIME IN MINUTES V-2 V-3 V-4 V-5
CELLS INCLUDED

FIGURE 179

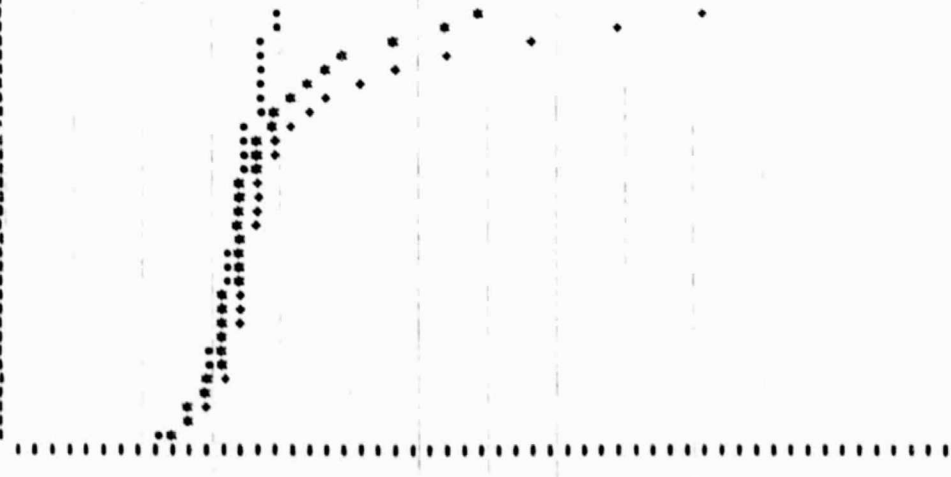
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 207A
 SHADOW PERIOD IS 19
 CYCLE NUMBER IS 3464
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

.06 1.52 2.98 4.45 5.91 7.38
 .79 2.25 3.72 5.18 6.64

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 23. 30. 44. 58. 73.
 8. 15. 23. 37. 51. 66.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 180

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 OF POOR QUALITY

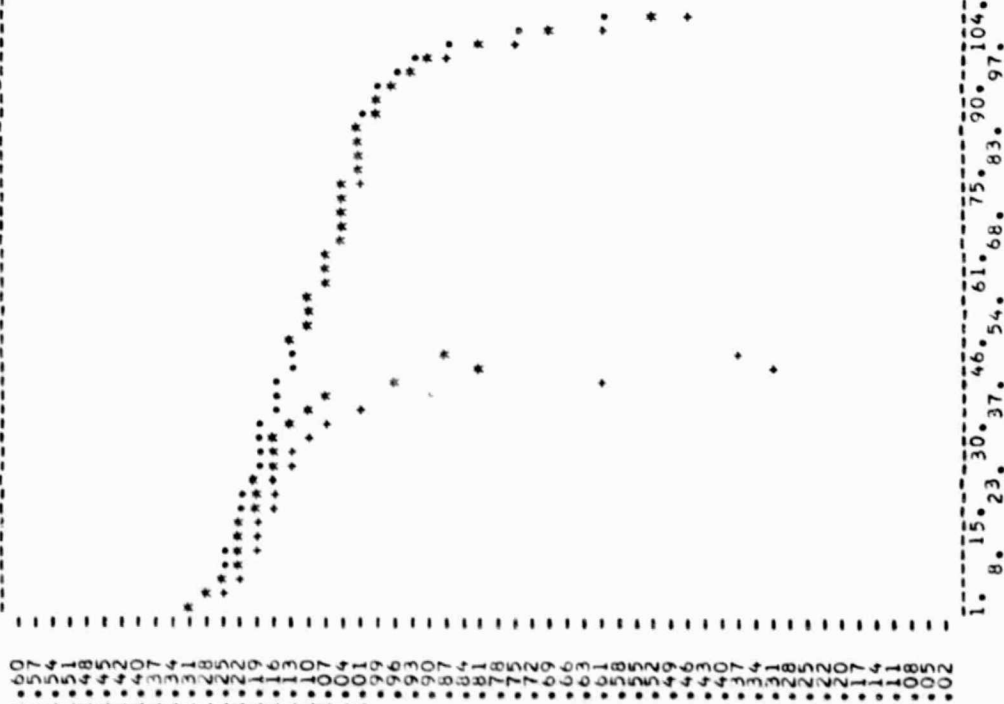
BACKLOG NUMBER 15 307A
DISPATCH DATE 15 3644

AMPERE HOUR OUT

| | | | | | | | |
|-----|------|------|------|------|------|------|-------|
| .00 | 1.47 | 2.96 | 4.41 | 5.75 | 7.22 | 8.69 | 10.16 |
| .73 | 2.20 | 3.67 | 5.02 | 6.49 | 7.96 | 9.43 | |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | A | P | A | C | I | T | Y | C | E | L | L | V | D | L | T | A | G | E | S | C | A | L | E | |
| 0 | 5 | 7 | 4 | 1 | 8 | 5 | 2 | 0 | 7 | 4 | 1 | 4 | 5 | 5 | 2 | 2 | 9 | 1 | 7 | 4 | 1 | 8 | 5 | 2 |

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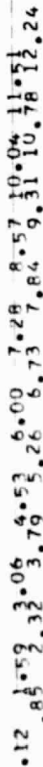


TIME IN MINUTES
CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 181

PACK NUMBER IS 207A
SHADOW PERIOD IS 22 4007
CYCLE NUMBER IS 15
DISCHARGE IS 6.

AMPERE HOUR OUT



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KEY
• HIGH CELL
• LOW CELL
• AVERAGE

[illegible]

U A I A C I T Y C E L L V D L T A G E S C A L E

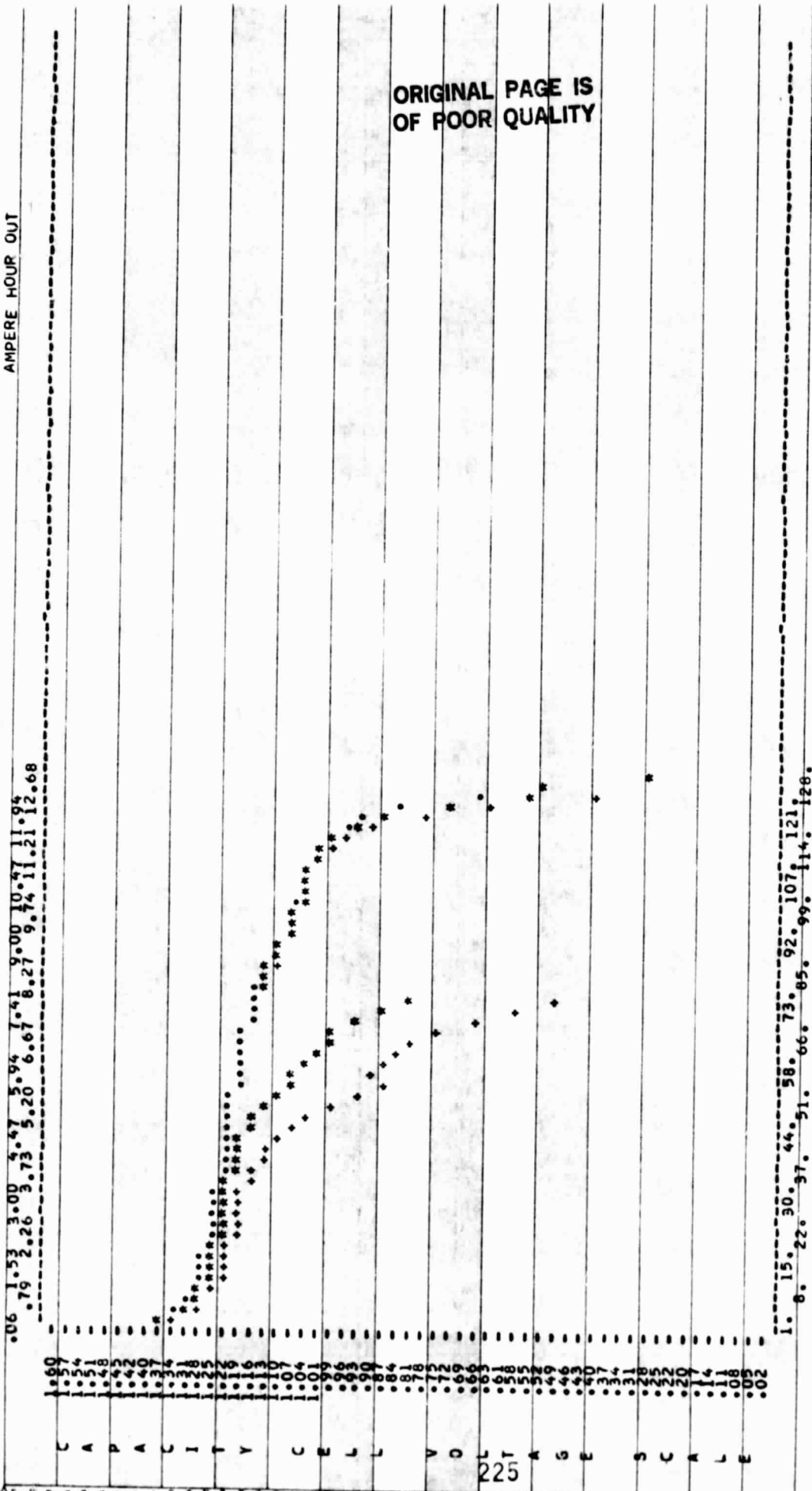
| | | | | | | | | | | | | | | | |
|----|---|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| 1. | 8 | 16 | 23 | 30 | 37 | 44 | 52 | 59 | 66 | 76 | 83 | 90 | 104 | 119 | 126 |
|----|---|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|

| | V-1 | V-2 | V-3 | V-4 | V-5 |
|---------------------------|-----|-----|-----|-----|-----|
| COUNTS PER MINUTE | 769 | 810 | 810 | 810 | 810 |
| TOTAL COUNTS | 769 | 810 | 810 | 810 | 810 |
| TIME IN MINUTES INCLUDED | 1 | 1 | 1 | 1 | 1 |
| AVERAGE COUNTS PER MINUTE | 769 | 810 | 810 | 810 | 810 |

FIGURE 183

PACK NUMBER IS 207A
SHADOW PERIOD IS 23
CYCLE NUMBER IS 4193
DISCHARGE RATE IS 6.

AMPERE HOUR OUT



| CELLS | TIME IN MINUTES | | | | |
|-------|-----------------|-----|-----|-----|-----|
| | INCLUDED | V-2 | V-3 | V-4 | V-5 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
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| 100 | | | | | |

FIGURE 184

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 207A
 POST CYCLING
 CYCLE NUMBER IS 4194
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

1.18 1.62 3.12 4.58 6.05 7.52 8.87 10.34 11.32
 .91 2.38 3.85 5.32 6.79 8.26 9.61 11.08

C 1.67
 A 1.54
 P 1.51
 A 1.48
 C 1.42
 I 1.40
 T 1.37
 Y 1.34
 C 1.31
 E 1.28
 L 1.25
 J 1.22
 L 1.19
 V 1.16
 C 1.13
 E 1.10
 L 1.07
 J 1.04
 L 1.01
 C 1.99
 E 1.96
 L 1.93
 J 1.90
 L 1.87
 V 1.84
 C 1.81
 E 1.78
 L 1.75
 J 1.72
 C 1.69
 E 1.66
 L 1.63
 J 1.60
 C 1.57
 E 1.54
 L 1.51
 J 1.48
 C 1.45
 E 1.42
 L 1.39
 J 1.36
 C 1.33
 E 1.30
 L 1.27
 J 1.24
 C 1.21
 E 1.18
 L 1.15
 J 1.12
 C 1.09
 E 1.06
 L 1.03
 J 1.00

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1. 0. 16. 22. 29. 37. 44. 51. 58. 66. 73. 80. 89. 97. 104. 113. 111.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 185

KEY
 * AVE END DISCHARGE VOLTAGE
 + AVE CELL VOLTAGE AT TRIP
 A AVE CELL VOLTAGE AT EOC
 B AVE AUX-ELECT. VOLT. AT FOD
 B AVE AUX-ELECT. VOLT. AT FOD
 PRESSURE TRANS. AT FOD

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 207A

DEPTH DISCHARGE 60
 TEMPERATURE 00
 TEMPERATURE RATE 12
 CATALOG 426012011AB
 SERIAL 90041001012.9015.19
 GENERAL ELECTRIC CELLS
 PROJECT AT5 F7G

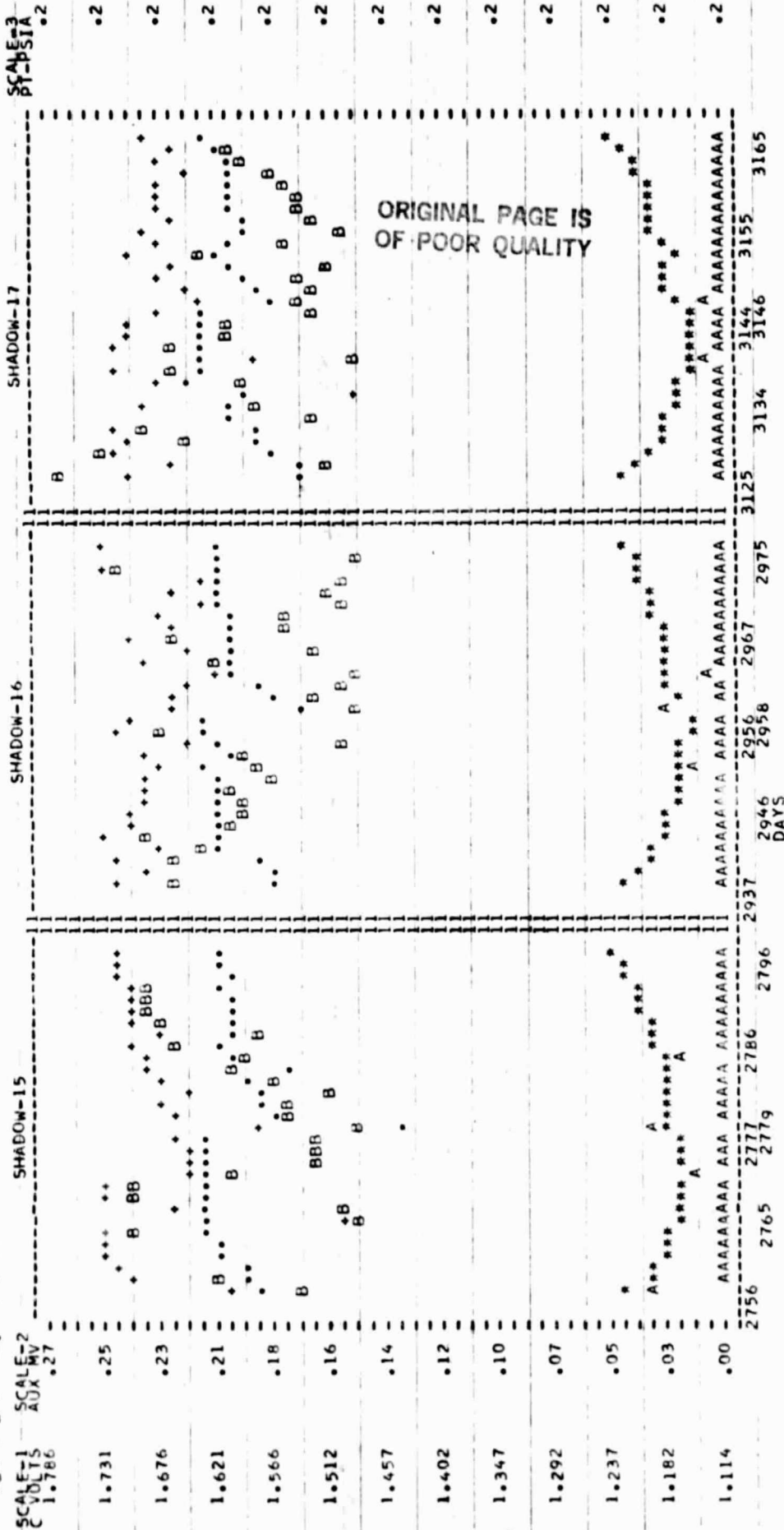
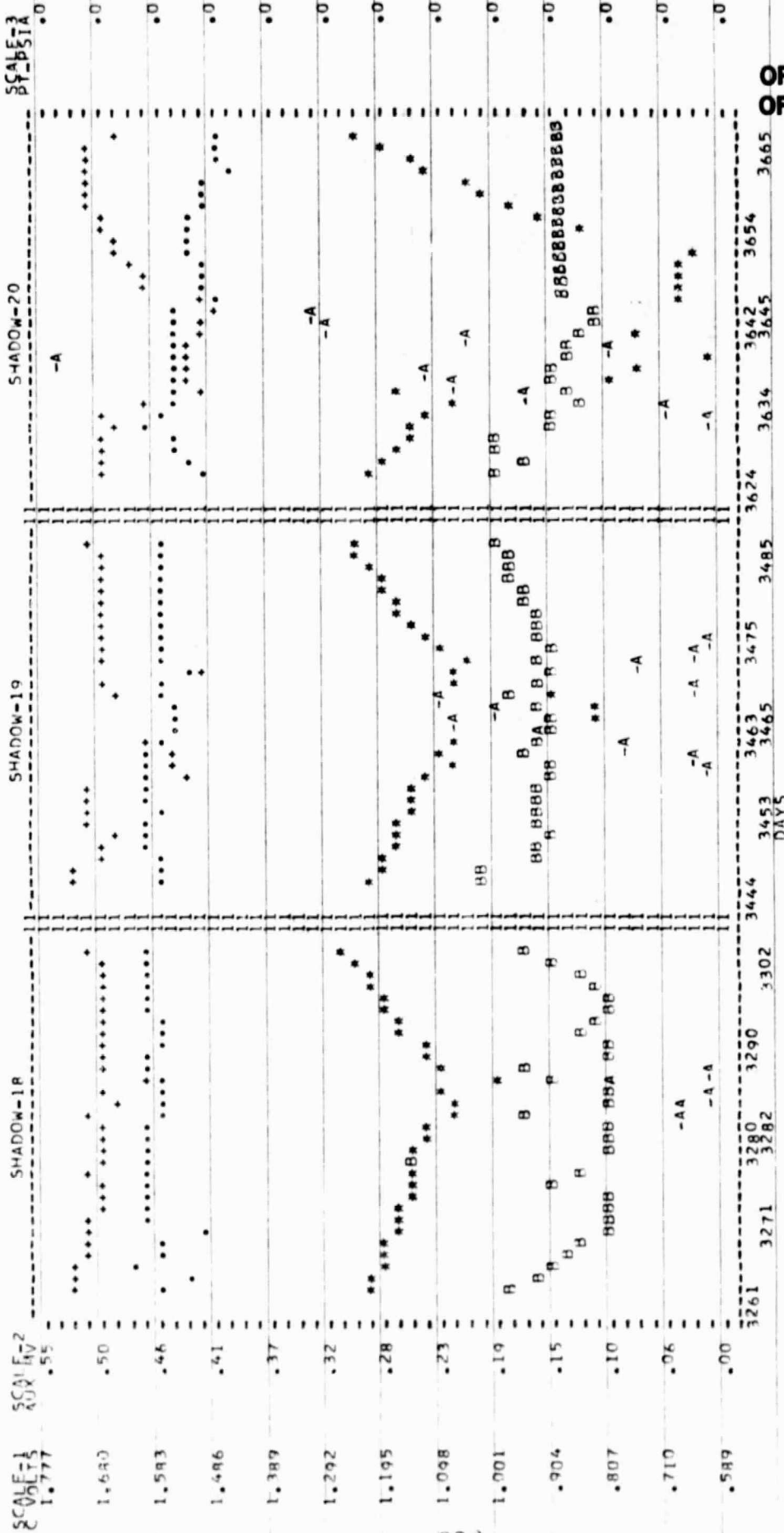


FIGURE 186

KEY
* AVE END DISCHARGE VOLTAGE
* AVE CELL VOLTAGE AT TRIP
* AVE CELL VOLTAGE AT EOD
* AVE AUX-ELECT. VOLT. AT EOD (-A, day values)
* AVE AUX-ELECT. VOLT. AT TRIP
* AVE AUX-ELECT. VOLT. AT EOD
* PRESSURE TRANS. AT EOD
* PRESSURE TRANS. AT TRIP

DEPTH DISCHARGE 60
TEMPERATURE 00
AMPERE RATE 12
CATALOG 428012AB
SERIAL 90041001012.9015.19
GENERAL ELECTRIC CELLS
PROJECT AYS F/G

PACK = 207A



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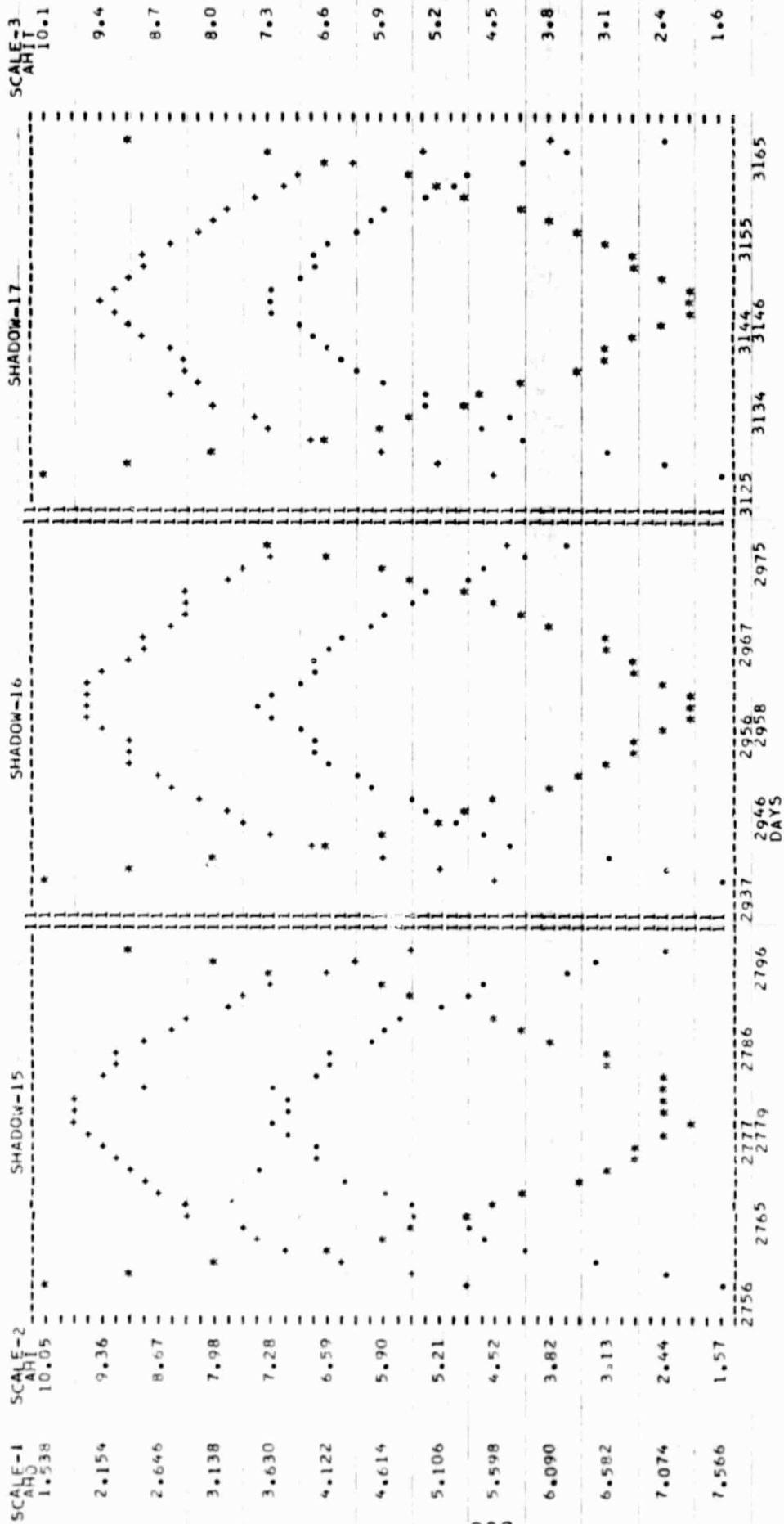
FIGURE 187

KEY
 * AHO
 * AHI-TOTAL
 * AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 207A

DEPTH DISCHARGE 60
 TEMPERATURE 00
 AMPERE RATE 12
 CATALOG 428012AB
 SERIAL 9004:10010,12,9015,19
 GENERAL ELECTRIC CELLS
 PROJECT ATS F/G



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FIGURE 189

KEY
 * AHI
 * AHI-TOTAL
 * AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 00
 AMPERE RATE 12
 CATALOG 428012AR
 SERIAL 900410010
 GENERAL ELECTRIC CELLS
 PROJECT AHS F/G

PACK = 207A

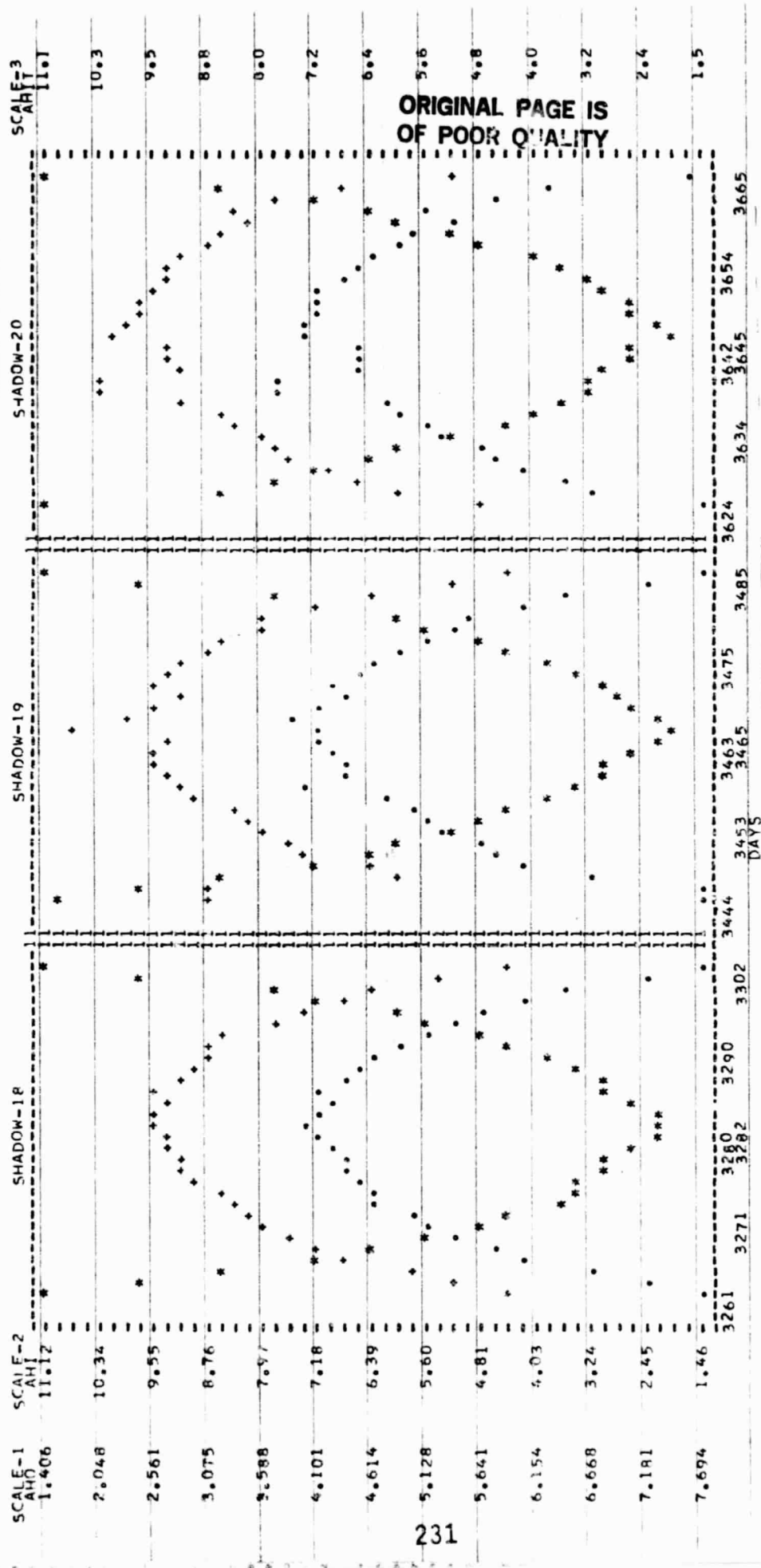


FIGURE 190

KEY
 * AHI - TOTAL
 * AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 00
 AMPERE RATE 12
 CATHODE LOG 428012AB
 SERIAL 9061601012-0015.19
 GENERAL ELECTRIC CELLS
 PROJECT ATIS F/G

PACK = 207A

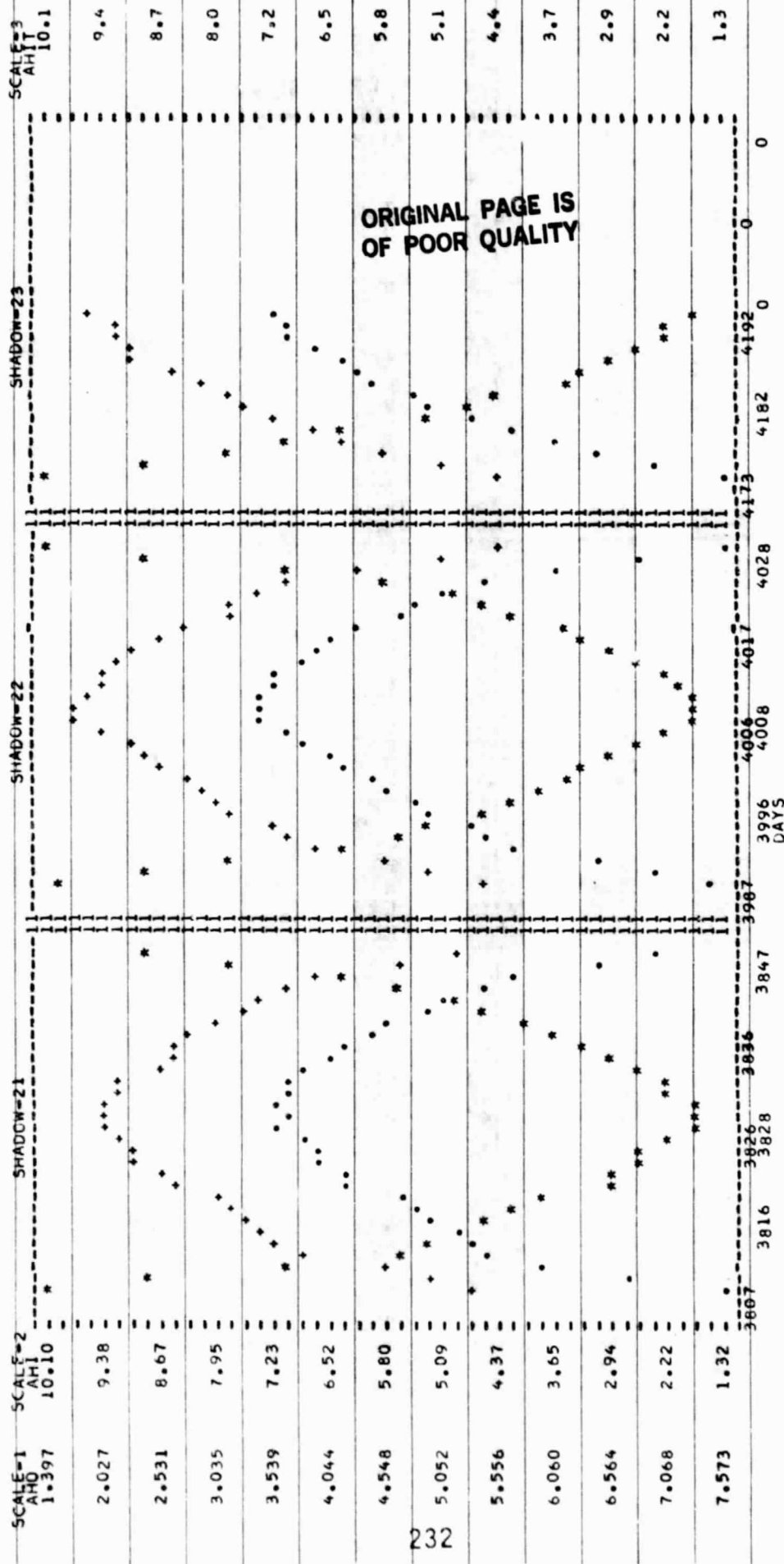


FIGURE 191

2. Pack 208A, 5-cells

a. Cell information: (Same as Pack 207A, Section V. F. 1.).

b. Parameters:

| | | | |
|--------------------------|-----|------------------------------|-----|
| Depth of Discharge (%) | 80 | Float/Trickle Current (amps) | .20 |
| Charge Control | AE | Auxiliary Electrode:* | |
| Charge Current (amps) | 3.0 | Resistance (ohms) | 300 |
| Discharge Current (amps) | 8.0 | Trip Voltage (mv) | 150 |
| Temperature (°C) | 0 | | |

*--Cells 2 and 3.

c. Capacity checks: (Discharge to .50 volts any cell).

| | Cell**
1 | Cell
2 | Cell
3 | Cell**
4 | Cell
5 | ah
out |
|---------------------------|-------------|-----------|-----------|-------------|-----------|-----------|
| Shadow 5 | .815 | .669 | .479 | .383 | .938 | 16.57 |
| Shadow 6 | .853 | .413 | .038 | .199 | .834 | 16.66 |
| Shadow 7 | .959 | .504 | .517 | .899 | .870 | 15.97 |
| Shadow 8 | .910 | .385 | .419 | .777 | .805 | 14.60 |
| Shadow 9 | .940 | .500 | .490 | .720 | .660 | 15.78 |
| Shadow 10 | .885 | .112 | .170 | .534 | .807 | 16.75 |
| Shadow 11 | .954 | .468 | .650 | .839 | .749 | 15.70 |
| Shadow 12 | .899 | .243 | .433 | .746 | .566 | 15.41 |
| Shadow 13 | .873 | .204 | .319 | .750 | .556 | 15.72 |
| Shadow 14 | .935 | .371 | .358 | .479 | .479 | 15.14 |
| Shadow 15 (Figure 192) | .366 | .787 | .751 | .744 | .819 | 14.19 |
| Shadow 16 (Figure 193) | .474 | .921 | .931 | .913 | .947 | 13.53 |
| Shadow 17 (Figure 194) | 11.34 | .756 | .700 | .299 | .837 | 13.04 |
| Shadow 18 (Figure 195) | 1.013 | .829 | .794 | .386 | .953 | 12.84 |
| Shadow 19 (Figure 196) | 1.128 | 1.114 | 1.106 | .463 | 1.149 | 9.39 |
| Shadow 20 (Figure 197) | 9.97 | .317 | .493 | 7.63 | .851 | 13.74 |
| Shadow 21 (Figure 198) | 9.60 | .245 | .296 | 7.66 | .524 | 13.56 |
| Shadow 22 (Figure 199) | 8.58 | .326 | .365 | 7.28 | .485 | 13.03 |
| Shadow 23 (Figure 200) | 8.23 | 12.76 | 13.08 | 6.86 | 13.40 | |
| Post Cycling (Figure 201) | 10.01 | 12.60 | 13.16 | 8.40 | 12.60 | |

**--Low discharge voltage failures: Cell 1 (day 3134, shadow 17), cell 4 (day 3465, shadow 19); but cells allowed to continue cycling.

d. Test results during the Shadow Periods: (Figures 202 to 207)

(1) Cells 1 and 4 failed (below .50 volts during discharge) during shadows 17 and 19, respectively. As the cells were allowed to continue cycling, cell 1 did not fail again until day 3636 of shadow 20. Both cells experienced cell reversal during discharge; but did not short.

(2) Average End of Discharge Voltages: The reconditioning effect, due to the capacity checks and the daily discharges, resulted in higher average voltages during the second part of each shadow. The increase in this effect, following shadow 19, was the result of cells 2, 3, and 5 being discharged to a lower value during the capacity check than they were during the capacity check of shadow 19.

(3) Average Cell Voltages at Trip and End of Charge: The end of charge voltages were always higher than the trip voltages for the first 8 periods. This was reversed during all the succeeding periods. The end of charge voltages steadily increased each period until they became fairly constant at 1.560 volts during shadows 11 through 18. The low voltages of cells 1 and 5 are responsible for the reduction in this value during shadow 19. The trip voltages increased at the beginning of each period, starting with period 9, due to the auxiliary electrodes appearing to become "desensitized" during the preceding sun period. This condition lasted from 2 to 7 days into each shadow (9 through 17) before the electrodes regained their sensitivity. Following shadow 17, the cells (2 and 3) only exhibited a trip voltage of 150 mv when the cell voltages were approximately 1.65 volts.

(4) The pack was discontinued in the middle of shadow 23 in which each cell was discharged to .50 volts.

(5) Post Cycling: Capacities of the 3 unfailed cells averaged 12.79 ampere-hours following a 3.0 ampere charge to an auxiliary electrode voltage of 150 mv at 0°C.

e. Performance during Sun Periods: The pack began test with a shadow period and therefore completed 22 sun periods. The pressures, cell 1, did not exceed 10 psia during any period. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 15 through 22.

SUN PERIODS

| Voltages** | 15 | | 16 | | 17 | | 18 | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| | Start | End | Start | End | Start | End | Start | End |
| High | 1.633(3) | 1.627(4) | 1.621(2) | 1.650(4) | 1.665(2) | 1.585(2) | 1.644(3) | 1.569(4) |
| Average | 1.585 | 1.481 | 1.573 | 1.543 | 1.597 | 1.525 | 1.580 | 1.490 |
| Low | 1.434(1) | 1.416(1) | 1.430(1) | 1.448(1) | 1.463(1) | 1.447(5) | 1.447(1) | 1.405(5) |

| Voltages | 19 | | 20 | | 21 | | 22 | |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | Start | End | Start | End | Start | End | Start | End |
| High | 1.637(2) | 1.558(4) | 1.659(3) | 1.574(3) | 1.639(3) | 1.609(2) | 1.644(3) | 1.599(2) |
| Average | 1.538 | 1.477 | 1.545 | 1.489 | 1.536 | 1.502 | 1.535 | 1.500 |
| Low | 1.440(5) | 1.392(5) | 1.442(5) | 1.389(5) | 1.417(5) | 1.377(5) | 1.436(5) | 1.401(5) |

**--() indicates which cell.

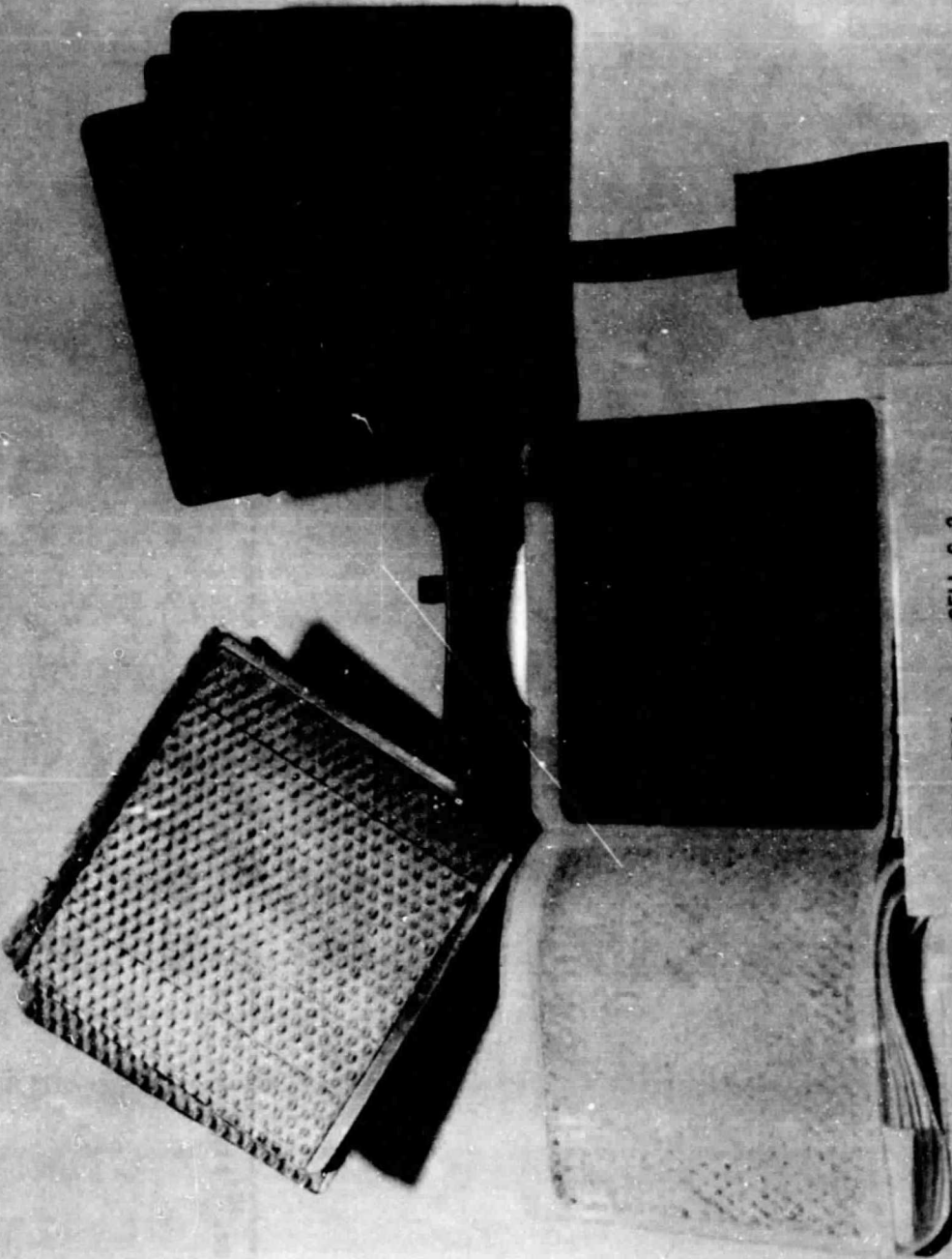
f. Cell Analysis:

(1) The following photograph shows the condition of the plates and separator of cell 2, as it was opened at Crane following completion of 22.5 shadow periods.

(2) Cells 3, 4, and 5 were returned to GSFC and cell 1 was disposed of as its pressure assembly broke-off at the base of the fill tube while the pack was being removed from its environmental chamber, following completion of the post cycling capacity test.

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BLACK AND WHITE PHOTOGRAPH



PACK 208A CELL C-2

Pack 208A, Cell 2, 22.5 shadow periods at 80 percent DOD, 0°C: Cell was damp, some loose active material located at bottom of uncoined positive plates, and weld of auxiliary electrode tab was weak.

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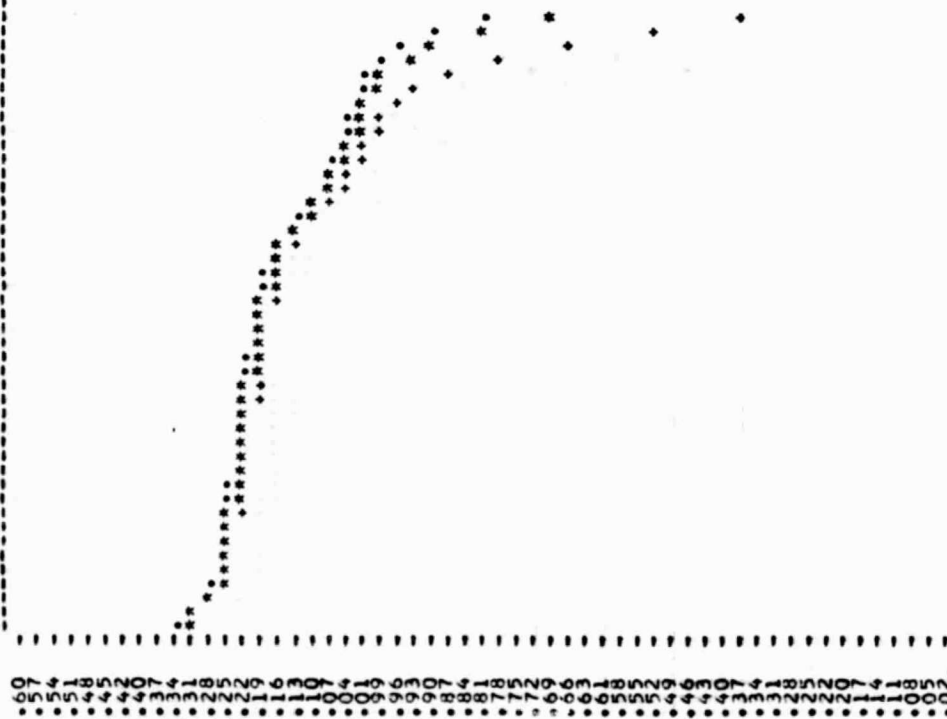
TEST NUMBER 15 4084
SHADOW PERIOD 15 15
CYCLE NUMBER 15 15
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

HIGH CELL
LOW CELL
AVERAGE

32 2.26 4.19 6.13 8.06 9.99 11.93 13.87 14.19
1.29 3.22 5.16 7.10 9.03 10.96 12.90

C
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1. 8. 15. 22. 30. 37. 45. 51. 58. 66. 73. 80. 87. 95. 102. 105.

TIME IN MINUTES
CELLS INCLUDED VI V2 V3 V4 V5

FIGURE 192

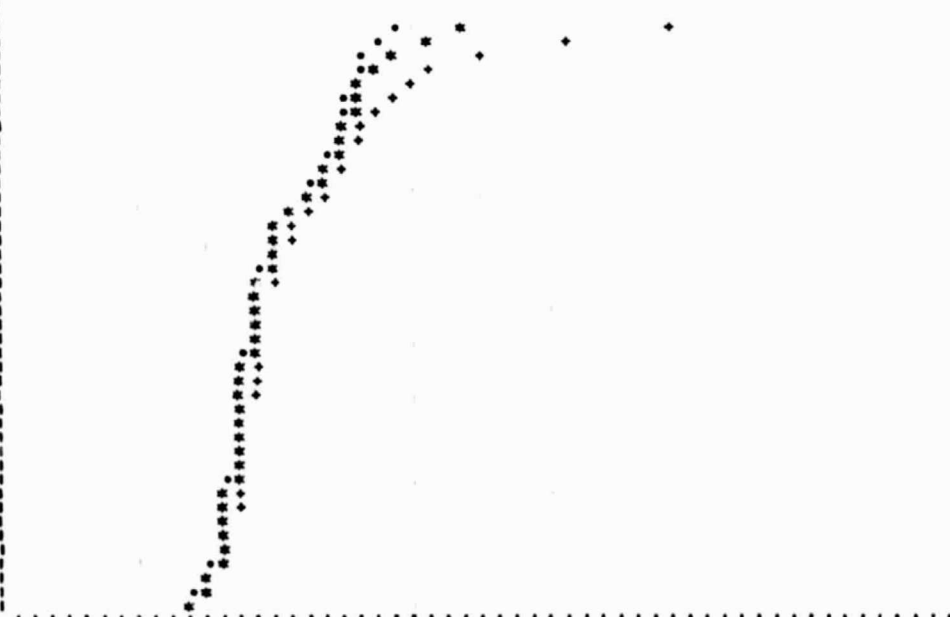
PACK NUMBER IS 208A
 SHADOW PERIOD IS 16
 CYCLE NUMBER IS 3957.
 DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY
 HIGH CELL
 LOW CELL
 AVERAGE

32 2.25 4.19 6.12 8.05 9.98 11.91 13.52
 1.29 3.22 5.15 7.08 9.02 10.95 12.88

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 9. 16. 23. 30. 37. 45. 52. 59. 73. 81. 88. 95. 100.

TIME IN MINUTES
 CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 193

PACK NUMBER IS 208A
SHADOW PERIOD IS 17
CYCLE NUMBER IS 3145.
DISCHARGE RATE IS 8.

AMPERE HOUR OUIT

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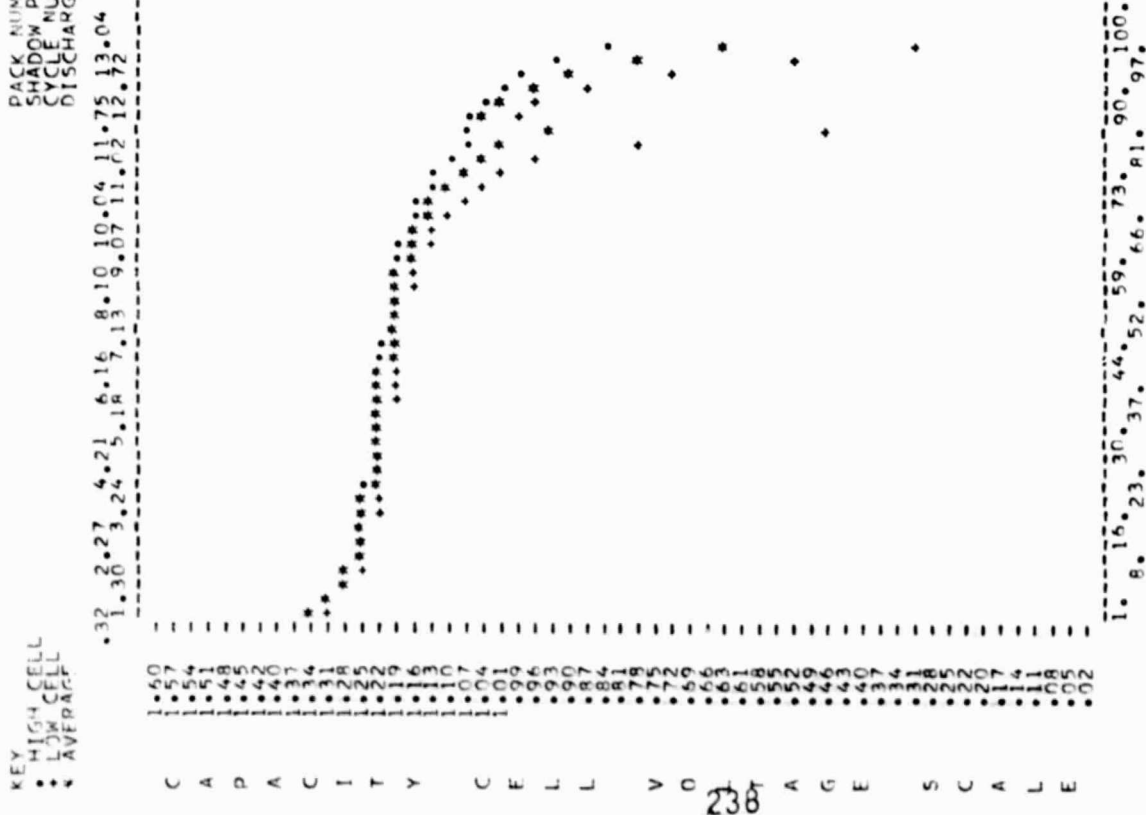


FIGURE 194

PACK NUMBER IS 208A
SHADOW PERIOD IS 18
CYCLE NUMBER IS 03281
DISCHARGE RATE IS 8.

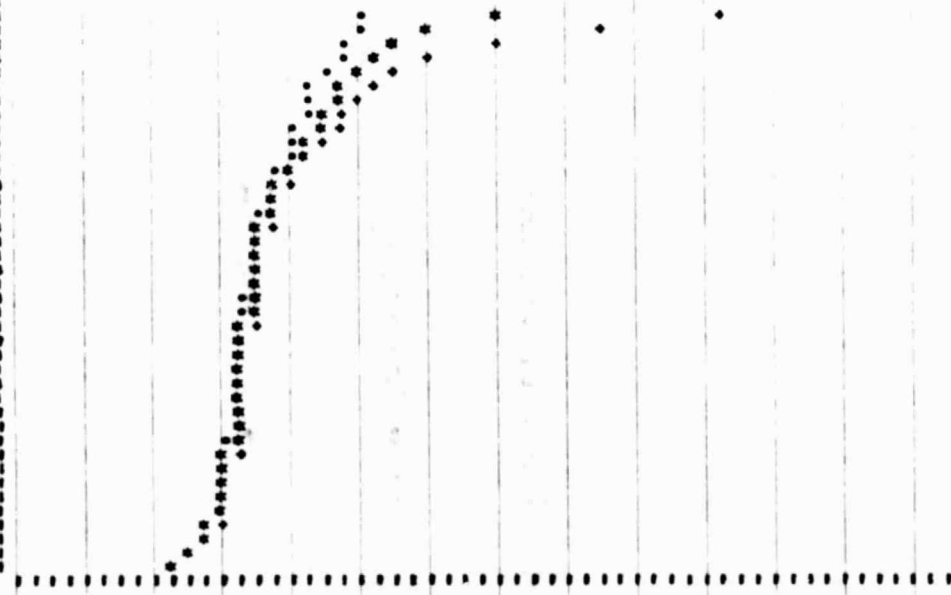
AMPERE HOUR OUT

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KEY
• HIGH CELL
• LOW CELL
• AVERAGE

32 2.25 4.17 6.10 8.03 9.95 11.88
1.26 3.21 5.14 7.06 8.99 10.92 12.84

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1. 9. 16. 23. 30. 37. 45. 52. 59. 67. 73. 81. 88. 95.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 195

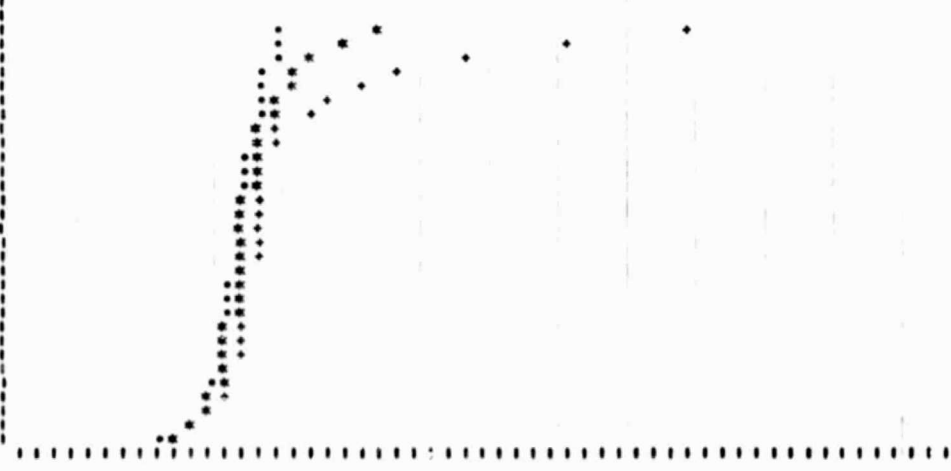
PACK NUMBER IS 208A
 SHADOW PERIOD IS 19
 CYCLE NUMBER IS 3464
 DISCHARGE RATE IS 8.

AMPERE HOUR OUT

08 2.00 3.93 5.86 7.78 9.39
 1.04 2.97 4.89 6.82 8.74

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 30. 44. 58. 70.
 2. 8. 23. 37. 51. 66.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 196

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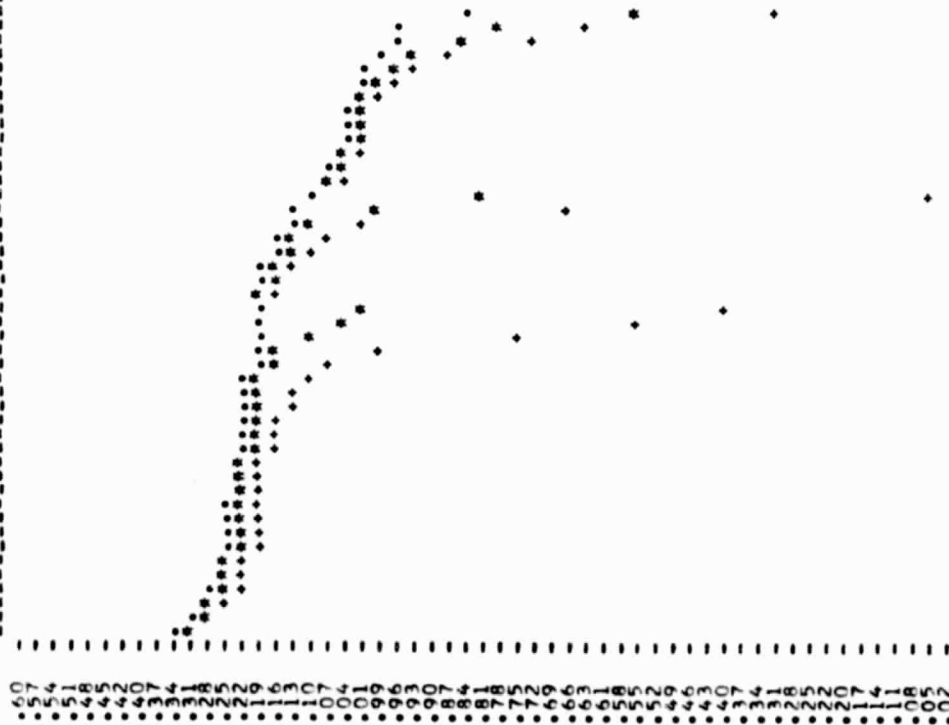
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 208A
 SHADOW PERIOD IS 20
 CYCLE NUMBER IS 3644
 DISCHARGE RATE IS 8.

AMPERE HOUR OUT

24 2.17 4.10 6.02 7.71 9.65 11.33 13.25 13.74
 1.20 3.13 5.06 6.99 8.68 10.37 12.30

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1. 9. 15. 22. 30. 37. 44. 51. 59. 65. 73. 80. 87. 94. 102. 111.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 197

ORIGINAL PAGE IS
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PACK NUMBER IS 208A
STATION NUMBER IS 213827
CYCLE NUMBER IS 8.
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

2.18 4.11 6.05 7.99 9.68 11.62 13.56
1.21 3.14 5.08 7.02 8.96 10.65 12.59

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0.72
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0.63
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
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0.31
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0.25
0.22
0.20
0.17
0.14
0.11
0.08
0.05
0.02

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1. 9. 16. 23. 30. 37. 45. 52. 64. 71. 78. 85. 93. 107.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 198

PAGE NUMBER IS 208A
 SHADOW PERIOD IS 22
 CYCLE NUMBER IS 4007
 DISCHARGE RATE IS 8.

AMPERE HOUR OUT

1. 13.10 4.05 5.99 7.93 9.79 11.73 13.03
 1.13 3.07 5.02 6.96 8.62 10.77 12.70

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G
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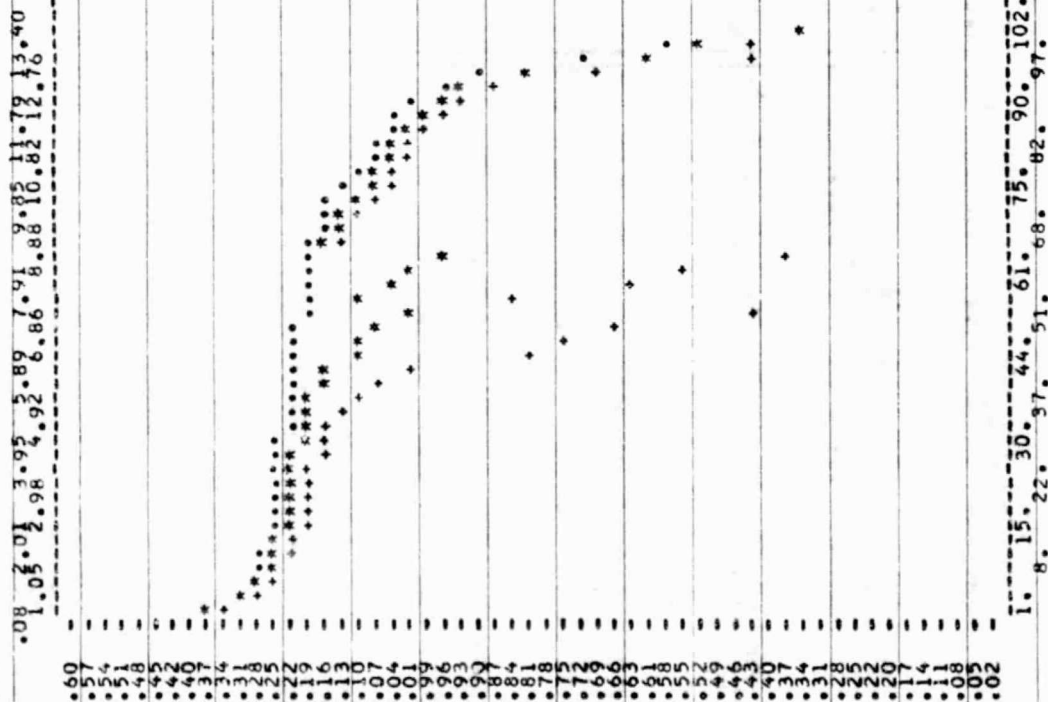
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1. 8. 15. 22. 29. 37. 44. 51. 58. 63. 73. 80. 87. 94. 104.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 199

AMPERE HOUR OUT



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FIGURE 200

PACK NUMBER IS 208A
POST CYCLING IS 4194
CYCLE NUMBER IS 4194
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

| | | | | | | | |
|----|------|------|------|------|-------|-------|-------|
| 32 | 2.25 | 4.19 | 6.13 | 8.07 | 10.01 | 11.95 | 13.16 |
| 26 | 2.29 | 3.23 | 5.16 | 7.10 | 9.04 | 10.98 | 12.84 |

| | | |
|---|----|----|
| C | 1 | 69 |
| A | 2 | 74 |
| A | 3 | 18 |
| A | 4 | 20 |
| A | 5 | 40 |
| A | 6 | 37 |
| C | 7 | 1 |
| I | 8 | 14 |
| I | 9 | 25 |
| T | 10 | 22 |
| T | 11 | 16 |
| Y | 12 | 13 |
| Y | 13 | 10 |
| Y | 14 | 07 |
| C | 15 | 04 |
| C | 16 | 01 |
| E | 17 | 99 |
| E | 18 | 96 |
| L | 19 | 90 |
| L | 20 | 87 |
| V | 21 | 84 |
| V | 22 | 81 |
| V | 23 | 75 |
| O | 24 | 72 |
| O | 25 | 69 |
| O | 26 | 66 |
| I | 27 | 63 |
| T | 28 | 58 |
| T | 29 | 55 |
| A | 30 | 52 |
| A | 31 | 49 |
| G | 32 | 46 |
| G | 33 | 43 |
| E | 34 | 40 |
| E | 35 | 37 |
| S | 36 | 34 |
| C | 37 | 31 |
| C | 38 | 28 |
| C | 39 | 25 |
| A | 40 | 22 |
| A | 41 | 20 |
| L | 42 | 17 |
| L | 43 | 14 |
| E | 44 | 11 |
| E | 45 | 08 |
| E | 46 | 05 |

245

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| | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|-----|
| 1. | 15. | 29. | 44. | 58. | 72. | 87. | 96. |
| 0. | 0. | 22. | 36. | 51. | 65. | 80. | 94. |

| CELLS INCLUDED | TIME IN MINUTES | | | | |
|----------------|-----------------|-----|-----|-----|-----|
| | V-1 | V-2 | V-3 | V-4 | V-5 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
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| 98 | | | | | |
| 99 | | | | | |
| 100 | | | | | |

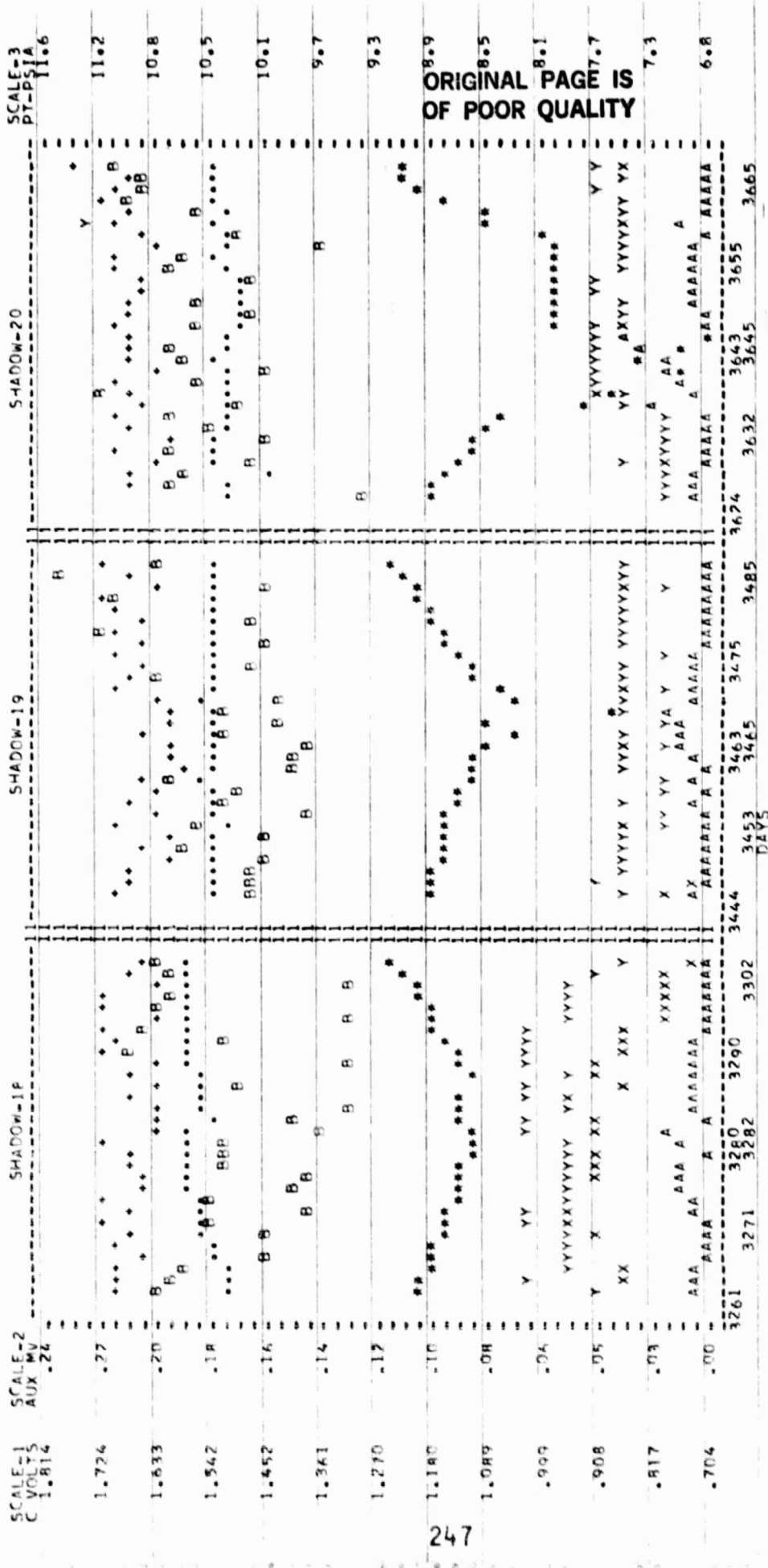
FIGURE 201

KFY
 * AVE END DISCHARGE VOLTAGE
 * AVE CELL VOLTAGE AT TRIP
 * AVE AUX-ELECT. VOLT. AT FOD (avg. value)
 * AVE AUX-ELECT. VOLT. AT TRIP
 * PRESSURE TRANS. AT FOD
 * PRESSURE TRANS. AT TRIP

SYNCHRONOUS OPBIT SHADOW PLOT

PACK = 208A

DEPTH DISCHARGE 80
 TEMPERATURE 00
 AMPERE RATE 12
 CATHODE 428012AB
 SERIAL 1000390006
 GENERAL ELECTRIC CELLS
 PROJECT K15 F76



Cell 4 Failed - Low Discharge Voltage - Day 3465

KEY

| | | | | |
|-------|-------------------|---------|-----------|---------|
| * AVE | AVE | END | DISCHARGE | VOLTAGE |
| * AVE | CELL VOLTAGE | AT TRIP | | |
| * AVE | AUXILIARY VOLT. | AT EOC | | |
| * AVE | ELECTRICAL TRANS. | AT FOP | | |
| * AVE | PRESSURE | TRANS. | AT FOP | |

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 208A

DEPTH DISCHARGE 80
TEMPERATURE 00
TEMPERATURE 12
CATHODE LOG 42012AB
SERIAL 10003900612
GENERAL ELECTRIC
PROJECT

| SCALE=1 | SCALE=2 | SHADOW=21 | SHADOW=22 | SHADOW=23 | SCALE=3 |
|---------|---------|-----------|-----------|-----------|---------|
| C | AUX | | | | PT-PSIA |
| 1.798 | MV | | | | 0 |
| 24 | | | | | |

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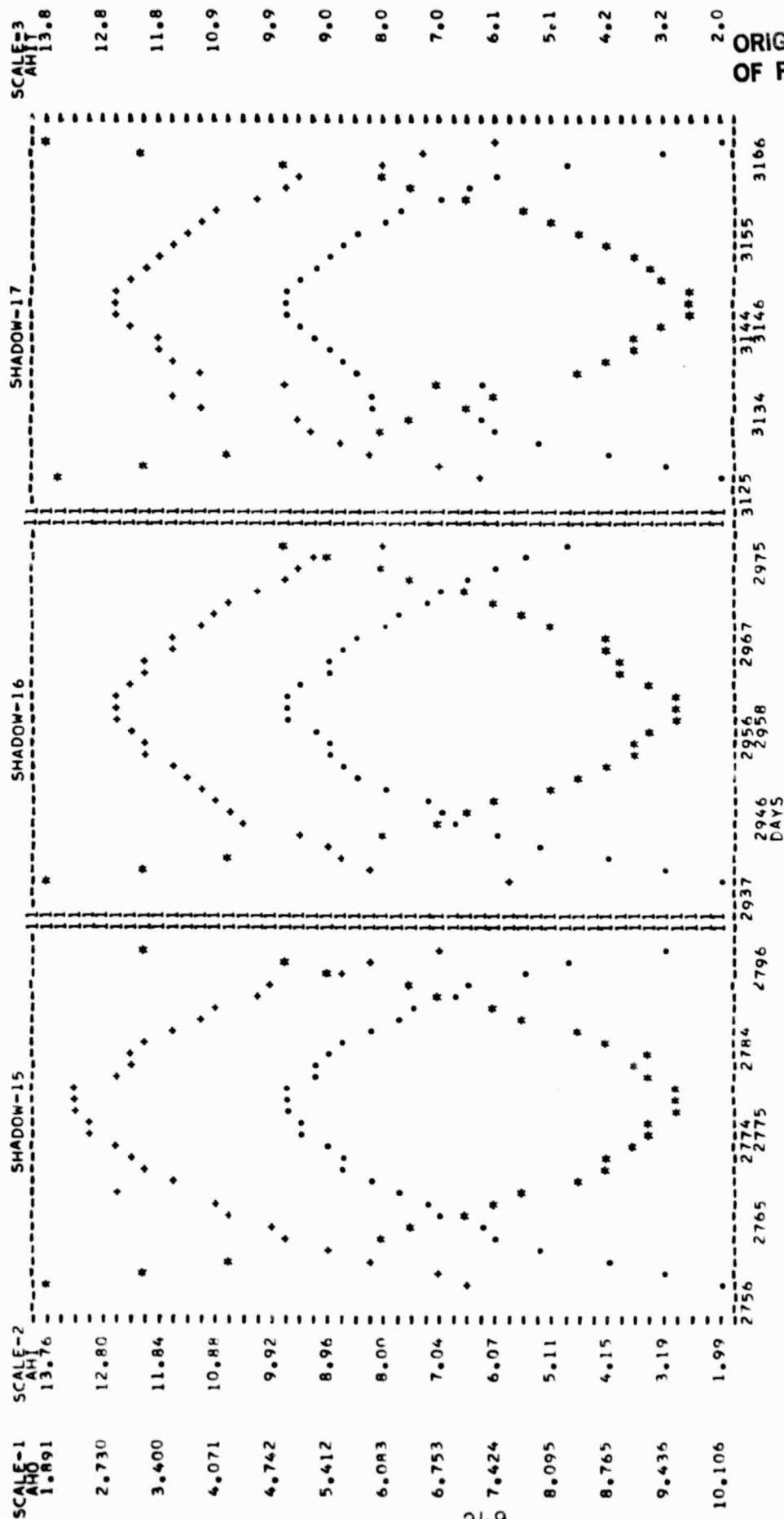
FIGURE 204

KEY
 * AHO-TOTAL
 * AHI AT TRIP
 * AHI AT F/G

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 208A

DEPTH DISCHARGE 80
 TEMPERATURE 00
 AMPERE RATE 12
 CATALOG 428012AB
 SERIAL 1000319006
 GENERAL ELECTRIC CELLS
 PROJECT AT5 F/G



ORIGINAL PAGE IS
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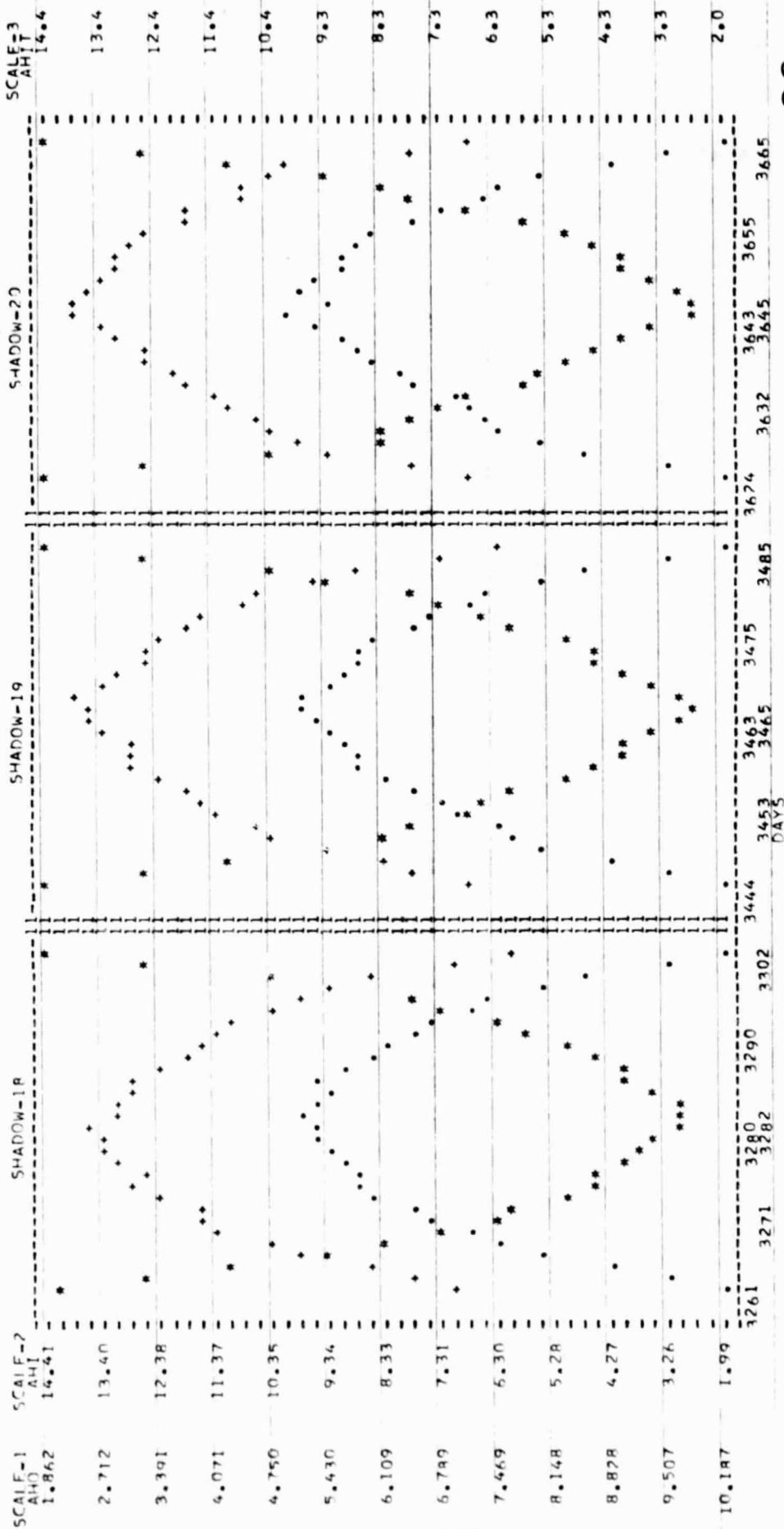
FIGURE 205

KEY
 * AHO
 * AHI-TOTAL
 * AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 208A

DEPTH DISCHARGE 80
 TEMPERATURE 00
 AMPERE RATE 12
 CATALOG 428012AB
 SERIAL 100039006
 GENERAL ELECTRIC CELLS
 PROJECT AHS F/G



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FIGURE 206

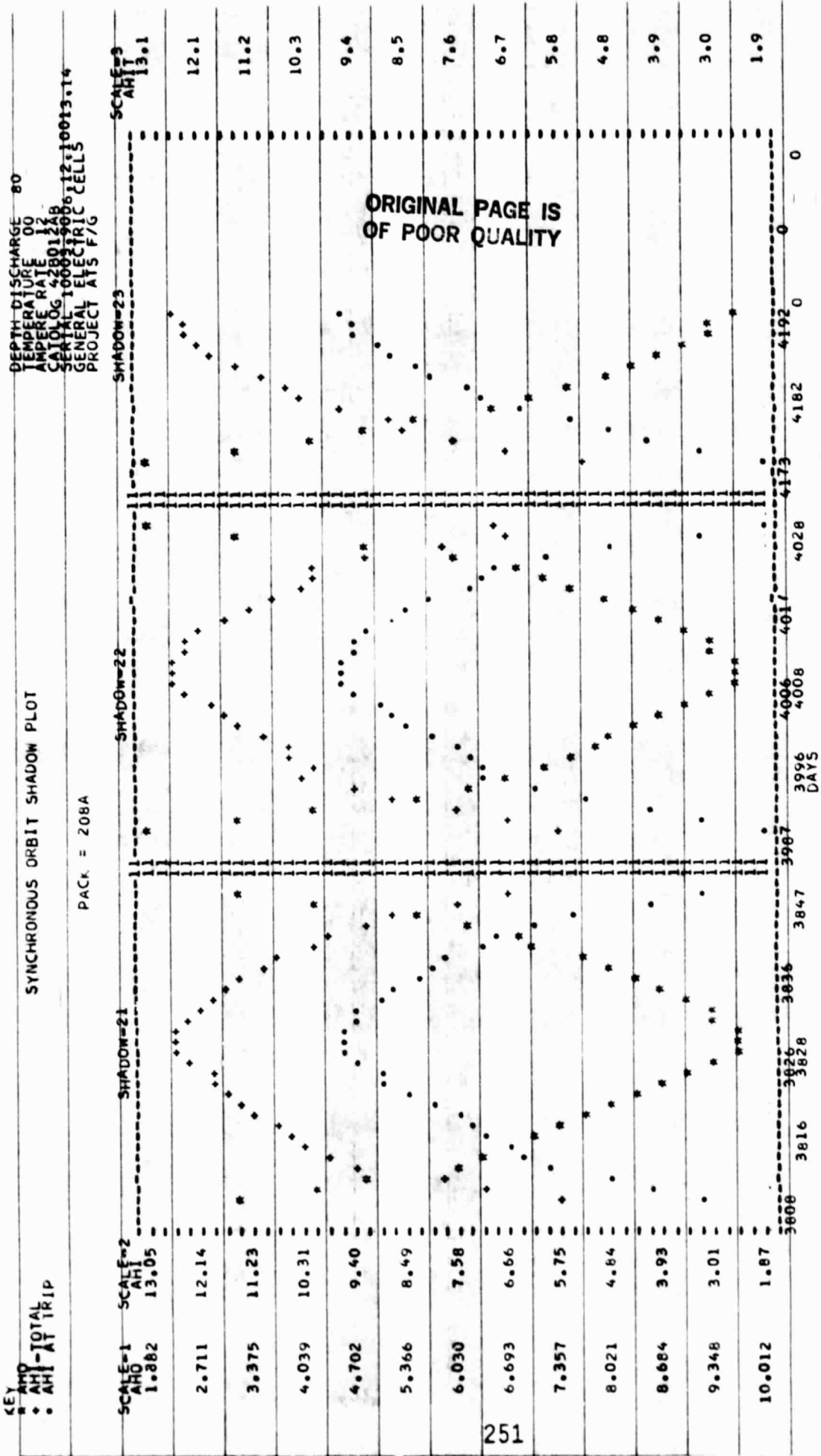


FIGURE 207

3. Pack 209A, 5-cells

a. Cell information: (Same as Pack 207A, Section V. F. 1.)

b. Parameters:

| | | | |
|--------------------------|-----|------------------------------|-----|
| Depth of Discharge (%) | 60 | Float/Trickle Current (amps) | .20 |
| Charge Control | AE | Auxiliary Electrode:* | |
| Charge Current (amps) | 3.0 | Resistance (ohms) | 300 |
| Discharge Current (amps) | 6.0 | Trip Voltage (mv) | 300 |
| Temperature (°C) | 20 | | |

*--Cells 3, 4 and 5.

c. Capacity checks: (Discharge to .50 volts any cell).

| | Cell* | Cell | Cell | Cell | Cell | ah
out |
|------------------------|-------|-------|-------|-------|-------|-----------|
| | 1 | 2 | 3 | 4 | 5 | |
| Shadow 5 | 1.010 | .960 | .961 | 1.001 | .345 | 15.04 |
| Shadow 6 | .995 | .937 | .934 | .986 | .357 | 14.64 |
| Shadow 7 | .991 | .947 | .918 | .977 | .451 | 14.40 |
| Shadow 8 | .970 | .930 | .882 | .953 | .402 | 14.45 |
| Shadow 9 | .958 | .838 | .141 | .910 | .200 | 13.84 |
| Shadow 10 | 1.027 | 1.025 | 1.008 | .995 | -.085 | 12.77 |
| Shadow 11 | 1.006 | .999 | .906 | .907 | -.178 | 12.77 |
| Shadow 12 | .789 | .990 | .984 | .281 | .153 | 12.64 |
| Shadow 13 | 1.005 | .991 | .874 | .358 | .391 | 11.93 |
| Shadow 14 | .945 | .980 | .974 | .047 | .868 | 11.67 |
| Shadow 15 (Figure 208) | 1.008 | 1.009 | 1.025 | .063 | .488 | 10.97 |
| Shadow 16 (Figure 209) | .995 | 1.014 | 1.021 | .061 | .686 | 10.61 |
| Shadow 17 (Figure 210) | 1.005 | 1.023 | 1.021 | .031 | .331 | 10.28 |
| Shadow 18 (Figure 211) | .992 | 1.017 | 1.015 | .251 | .766 | 9.94 |
| Shadow 19 (Figure 212) | 1.018 | 1.030 | 1.029 | .442 | .947 | 9.41 |
| Shadow 20 (Figure 213) | .998 | 1.032 | 1.037 | .320 | .895 | 9.06 |
| Shadow 21 (Figure 214) | 1.005 | 1.047 | 1.040 | .119 | .957 | 8.96 |
| Shadow 22 (Figure 215) | .972 | 1.053 | 1.058 | .006 | .936 | 8.37 |
| Shadow 23 (Figure 216) | .983 | 1.065 | 1.060 | .052 | .959 | 8.17 |
| Shadow 24 (Figure 217) | .997 | 1.067 | 1.068 | .020 | .988 | 7.82 |

**--Cell 1 leaking at base of fill tube prior to shadow 22.

d. Test results during the Eclipse Seasons: (Figures 218 to 225)

(1) Average End of Discharge Voltages: The reconditioning effect, due to the capacity checks, can be seen for each period. The average voltage increased by 40 mv the day following the capacity check during shadow 14 and 57 mv during shadow 24 excluding cell 1 which had an 8 mv increase.

(2) Average Cell Voltages at Trip and End of Charge: The end of charge voltages were higher than the trip voltages for shadows 1 through 7 and in the middle of shadows 14 and 15. Beginning with shadow 16, the trip voltages have consistently been higher. As indicative of the previous packs of this group, the higher trip voltages at the beginning of each shadow appears to be due to the auxiliary electrodes becoming "desensitized" during the preceding sun period. This condition has been present each shadow and the reason for the drop in the average auxiliary voltage at trip, during the last three shadows is due to cell 3. Its auxiliary voltage was very low (below 50 mv) except during the first 3 days of shadow 21, the first half of shadow 22, until 6 days prior to the capacity checks of shadows 23 and 24, and the last 11 days of shadow 24.

(3) The end of charge pressures, at the beginning of periods 5 through 8, were 100 psia or higher. They began to decrease as the auxiliary electrodes regained their sensitivity. During periods 9 through 21, the pressures remained constant throughout the periods even though the trip voltages were very high at the beginning of each period. Pressure data is not available following shadow 21 as cell 1 was found to be leaking at the base of its fill tube.

e. Performance during Sun Periods: The pack has completed 23 sun periods as it began test with a shadow period. The pressures, cell 1, never exceeded 15 psia during any sun period prior to period 21 when its pressure assembly began leaking. Beginning with period 8, various cells have exhibited high voltages at the start of the sun periods. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 15 through 23.

Sun Periods

| | | | 15 | | | 16 | | | 17 | | | 18 | | |
|-------------|----------|----------|----------|----------|--|----------|----------|--|----------|----------|--|----------|----------|--|
| Voltages*** | | | Start | End | | Start | End | | Start | End | | Start | End | |
| High | 1.463(2) | 1.398(1) | 1.493(2) | 1.412(2) | | 1.511(5) | 1.415(1) | | 1.580(5) | 1.396(1) | | 1.580(5) | 1.396(1) | |
| Average | 1.431 | 1.368 | 1.438 | 1.383 | | 1.454 | 1.378 | | 1.485 | 1.380 | | 1.485 | 1.380 | |
| Low | 1.399(1) | 1.352(5) | 1.404(1) | 1.356(4) | | 1.406(1) | 1.358(5) | | 1.406(1) | 1.365(3) | | 1.406(1) | 1.365(3) | |
| | | | 19 | | | 20 | | | 21 | | | 22 | | |
| Voltages | | | Start | End | | Start | End | | Start | End | | Start | End | |
| High | 1.530(2) | 1.406(1) | 1.565(2) | 1.399(2) | | 1.600(2) | 1.400(1) | | 1.588(2) | 1.416(1) | | 1.588(2) | 1.416(1) | |
| Average | 1.458 | 1.368 | 1.466 | 1.384 | | 1.511 | 1.372 | | 1.493 | 1.388 | | 1.493 | 1.388 | |
| Low | 1.419(3) | 1.349(5) | 1.386(4) | 1.347(1) | | 1.414(1) | 1.362(4) | | 1.404(1) | 1.367(4) | | 1.404(1) | 1.367(4) | |
| | | | 23 | | | | | | | | | | | |
| Voltages | | | Start | End | | | | | | | | | | |
| High | 1.577(2) | 1.416(1) | | | | | | | | | | | | |
| Average | 1.488 | 1.378 | | | | | | | | | | | | |
| Low | 1.404(1) | 1.363(4) | | | | | | | | | | | | |

***--() indicates which cell.

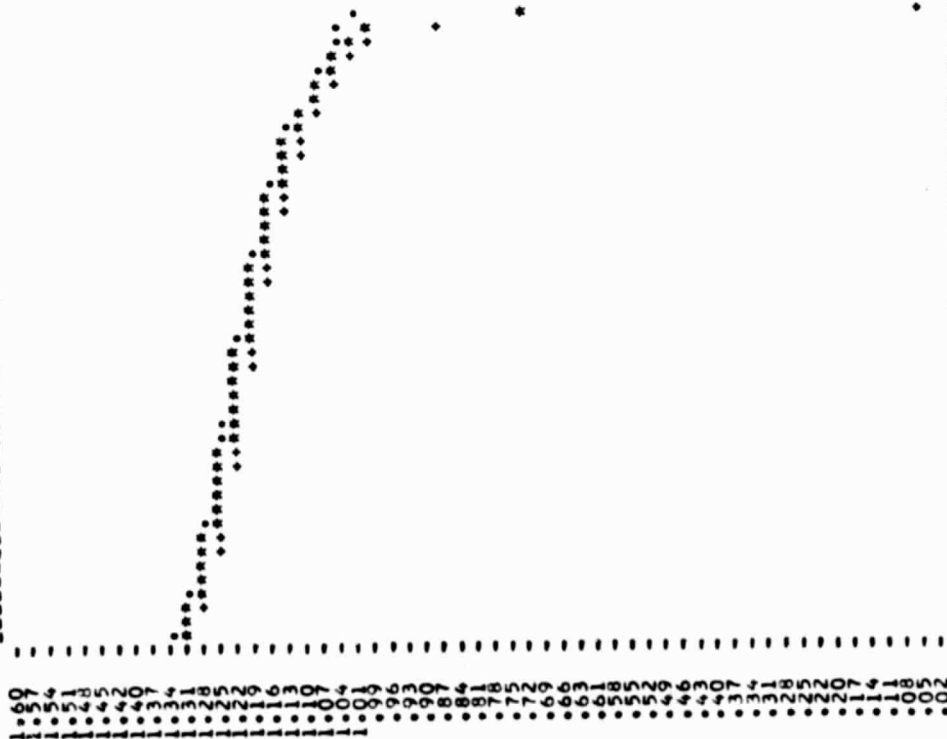
PACK NUMBER IS 209A
SHADOW PERIOD IS 15
CYCLE NUMBER IS 2776.
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KEY HIGH CELL
• LOW CELL
• AVERAGE

24 1.70 3.16 4.63 6.09 7.55 9.01 10.48 10.97
1.97 2.43 3.89 5.36 6.82 8.28 9.75

C A P A C I T Y C E L L V O L T A G E S C A L E



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1. 15. 30. 44. 59. 73. 87. 102. 107.
8. 23. 37. 51. 66. 80. 95.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4 V5

*** BCD READ - END OF FILE ON UNIT U002

FIGURE 208

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PACK NUMBER IS 209A
SHADOW PERIOD IS 16
CYCLE NUMBER IS 2957.
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KEY HIGH CELL
• LOW CELL
• AVERAGE

24 1.59 2.81 4.27 5.73 7.20 8.66 10.12 10.61
98 2.07 3.54 5.00 6.47 7.93 9.39

C A P A C I T Y C E L L V O L T A G E S C A L E
40
37
34
31
28
25
22
19
16
13
10
07
04
01
99
96
93
90
87
84
81
78
75
72
69
66
63
60
57
54
51
48
45
42
39
36
33
30
27
24
21
18
15
12
09
06
03
00

1. 8. 15. 24. 32. 39. 46. 53. 61. 68. 75. 82. 89. 96. 104. 108.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 209

ORIGINAL PAGE IS
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PACK NUMBER IS 209A
SHADOW PERIOD IS 17
CYCLE NUMBER IS 3145
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

24. 1.71 3.18 4.65 6.12 7.59 9.06 10.28
.98 2.45 3.92 5.39 6.86 8.32 9.79

C
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1. 60
2. 57
3. 54
4. 51
5. 48
6. 45
7. 42
8. 40
9. 37
10. 34
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12. 28
13. 25
14. 22
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16. 16
17. 13
18. 10
19. 07
20. 04
21. 01
22. 99
23. 96
24. 93
25. 90
26. 87
27. 84
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29. 78
30. 75
31. 72
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41. 42
42. 39
43. 36
44. 33
45. 30
46. 27
47. 24
48. 21
49. 18
50. 15
51. 12
52. 09
53. 06
54. 03
55. 00

1. 15. 22. 30. 37. 45. 51. 58. 66. 73. 80. 87. 94. 99.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 210

KEY
 * HIGH CELL
 + LOW CELL
 . AVERAGE

PACK NUMBER IS 209A
 SHADOW PERIOD IS 18
 CYCLE NUMBER IS 03281
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

1.8 1.62 3.11 4.57 6.04 7.50 8.97 9.94
 3.38 5.84 5.31 6.77 8.23 9.70

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 9. 15. 22. 29. 37. 46. 51. 58. 65. 73. 80. 87. 94. 97.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 211

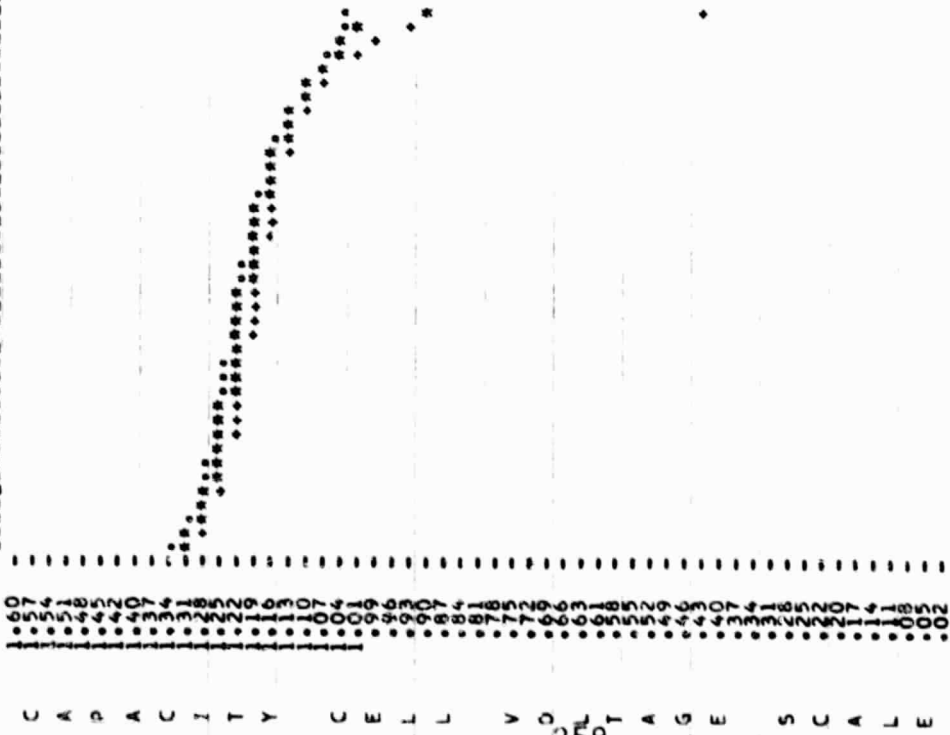
ORIGINAL PAGE IS
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PACK NUMBER IS 209A
 SHADOW PERIOD IS 19
 CYCLE NUMBER IS 3464
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

KEY
 HIGH CELL
 LOW CELL
 AVERAGE

1. 1.43 3.09 4.55 6.01 7.46 8.92 9.41
 .91 2.36 3.82 5.28 6.74 8.19



1. 8. 15. 22. 29. 37. 44. 51. 58. 65. 74. 80. 87. 92.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 212

ORIGINAL PAGE IS
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KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 209A
 SHADON PERIOD IS 21
 CYCLE NUMBER IS 3827
 DISCHARGE RATE IS 6.

AMPERE HOUR OUT

.18 1.64 3.11 4.57 6.03 7.50 8.96
 .21 2.37 3.84 5.30 6.77 8.23

C 1.57
 A 1.54
 P 1.51
 A 1.48
 C 1.45
 I 1.42
 T 1.37
 Y 1.34
 C 1.31
 I 1.28
 T 1.25
 Y 1.22
 C 1.19
 I 1.16
 T 1.13
 Y 1.10
 C 1.07
 I 1.04
 T 1.01
 Y .98
 C .95
 I .92
 T .89
 Y .86
 C .83
 I .80
 T .77
 Y .74
 C .71
 I .68
 T .65
 Y .62
 C .59
 I .56
 T .53
 Y .50
 C .47
 I .44
 T .41
 Y .38
 C .35
 I .32
 T .29
 Y .26
 C .23
 I .20
 T .17
 Y .14
 C .11
 I .08
 T .05
 Y .02

ORIGINAL PAGE IS
 OF POOR QUALITY

1. 8. 15. 22. 30. 37. 44. 52. 58. 66. 73. 80. 87.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 214

REF. HIGH CELL
* LOW CELL
* AVERAGE

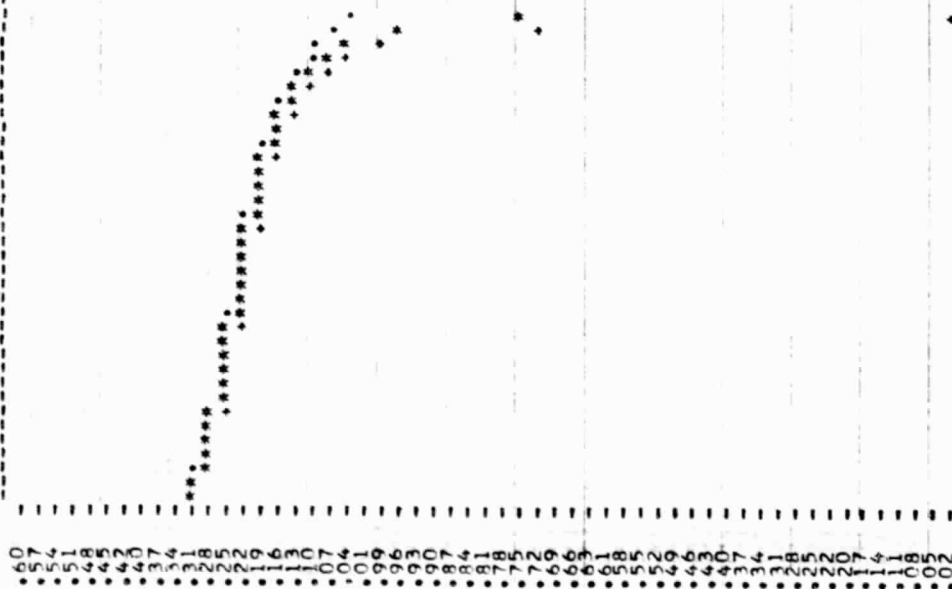
PACK NUMBER IS 309A
SHADOW PERIOD IS 22
CYCLE NUMBER IS 4007
DISCHARGE RATE IS 6.

WQEC/C 61-120A

AMPERE HOUR OUT

.06 1.52 2.98 4.45 5.92 7.39 8.37
.78 2.25 3.72 5.18 6.65 8.12

C A P A C I T Y C E L L V O L T A G E S C A L E



ORIGINAL PAGE IS
OF POOR QUALITY

1. 8. 15. 22. 29. 37. 44. 51. 58. 65. 73. 81. 82.

TIME IN MINUTES
CELLS INCLUDED A-1 V-2 V-3 V-4 V-5

FIGURE 214

DATA NUMBER 15 (94)
 STATION 15 (94)
 CYCLE NUMBER 15 (94)
 DISTANCE 15 (94)

AMPERE HOUR OUT

1. 1.34 1.07 4.07 5.73 1.14 2.17

2. 1.07 1.07 4.07 5.73 1.14 2.17

3. 1.07 1.07 4.07 5.73 1.14 2.17

4. 1.07 1.07 4.07 5.73 1.14 2.17

5. 1.07 1.07 4.07 5.73 1.14 2.17

6. 1.07 1.07 4.07 5.73 1.14 2.17

7. 1.07 1.07 4.07 5.73 1.14 2.17

8. 1.07 1.07 4.07 5.73 1.14 2.17

9. 1.07 1.07 4.07 5.73 1.14 2.17

10. 1.07 1.07 4.07 5.73 1.14 2.17

11. 1.07 1.07 4.07 5.73 1.14 2.17

12. 1.07 1.07 4.07 5.73 1.14 2.17

13. 1.07 1.07 4.07 5.73 1.14 2.17

14. 1.07 1.07 4.07 5.73 1.14 2.17

15. 1.07 1.07 4.07 5.73 1.14 2.17

16. 1.07 1.07 4.07 5.73 1.14 2.17

17. 1.07 1.07 4.07 5.73 1.14 2.17

18. 1.07 1.07 4.07 5.73 1.14 2.17

19. 1.07 1.07 4.07 5.73 1.14 2.17

20. 1.07 1.07 4.07 5.73 1.14 2.17

21. 1.07 1.07 4.07 5.73 1.14 2.17

22. 1.07 1.07 4.07 5.73 1.14 2.17

23. 1.07 1.07 4.07 5.73 1.14 2.17

24. 1.07 1.07 4.07 5.73 1.14 2.17

25. 1.07 1.07 4.07 5.73 1.14 2.17

26. 1.07 1.07 4.07 5.73 1.14 2.17

27. 1.07 1.07 4.07 5.73 1.14 2.17

28. 1.07 1.07 4.07 5.73 1.14 2.17

29. 1.07 1.07 4.07 5.73 1.14 2.17

30. 1.07 1.07 4.07 5.73 1.14 2.17

31. 1.07 1.07 4.07 5.73 1.14 2.17

32. 1.07 1.07 4.07 5.73 1.14 2.17

33. 1.07 1.07 4.07 5.73 1.14 2.17

34. 1.07 1.07 4.07 5.73 1.14 2.17

35. 1.07 1.07 4.07 5.73 1.14 2.17

36. 1.07 1.07 4.07 5.73 1.14 2.17

37. 1.07 1.07 4.07 5.73 1.14 2.17

38. 1.07 1.07 4.07 5.73 1.14 2.17

39. 1.07 1.07 4.07 5.73 1.14 2.17

40. 1.07 1.07 4.07 5.73 1.14 2.17

41. 1.07 1.07 4.07 5.73 1.14 2.17

42. 1.07 1.07 4.07 5.73 1.14 2.17

43. 1.07 1.07 4.07 5.73 1.14 2.17

44. 1.07 1.07 4.07 5.73 1.14 2.17

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DATA NUMBER 15 (94)
 STATION 15 (94)
 CYCLE NUMBER 15 (94)
 DISTANCE 15 (94)

FIGURE 216

ORIGINAL PAGE IS
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24
CYCLE NUMBER IS 24
DISCHARGE RATE IS 6.

AMPERE HOUR OUT

FROM CELL
AVERAGE

24 1.71 3.17 4.64 6.11 7.57 7.82
.97 2.44 3.91 5.38 6.84

C 1.67
A 1.51
P 1.48
A 1.55
C 1.52
T 1.77
T 1.48
Y 1.55
C 1.52
E 1.52
L 1.52
L 1.52
V 1.52
O 1.52
J 1.52
T 1.52
A 1.52
G 1.52
E 1.52
S 1.52
C 1.52
A 1.52
L 1.52
E 1.52

1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 75.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 217

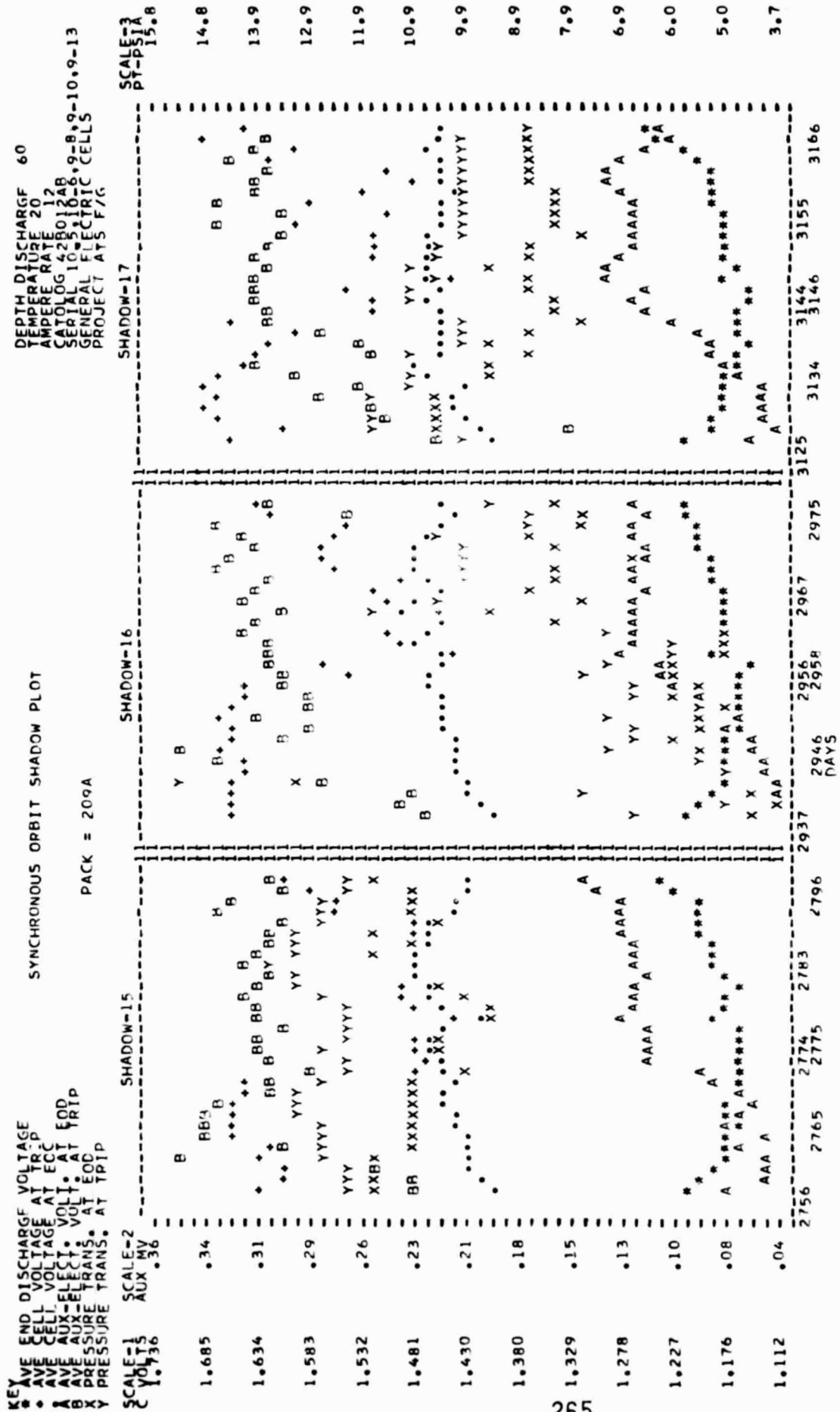


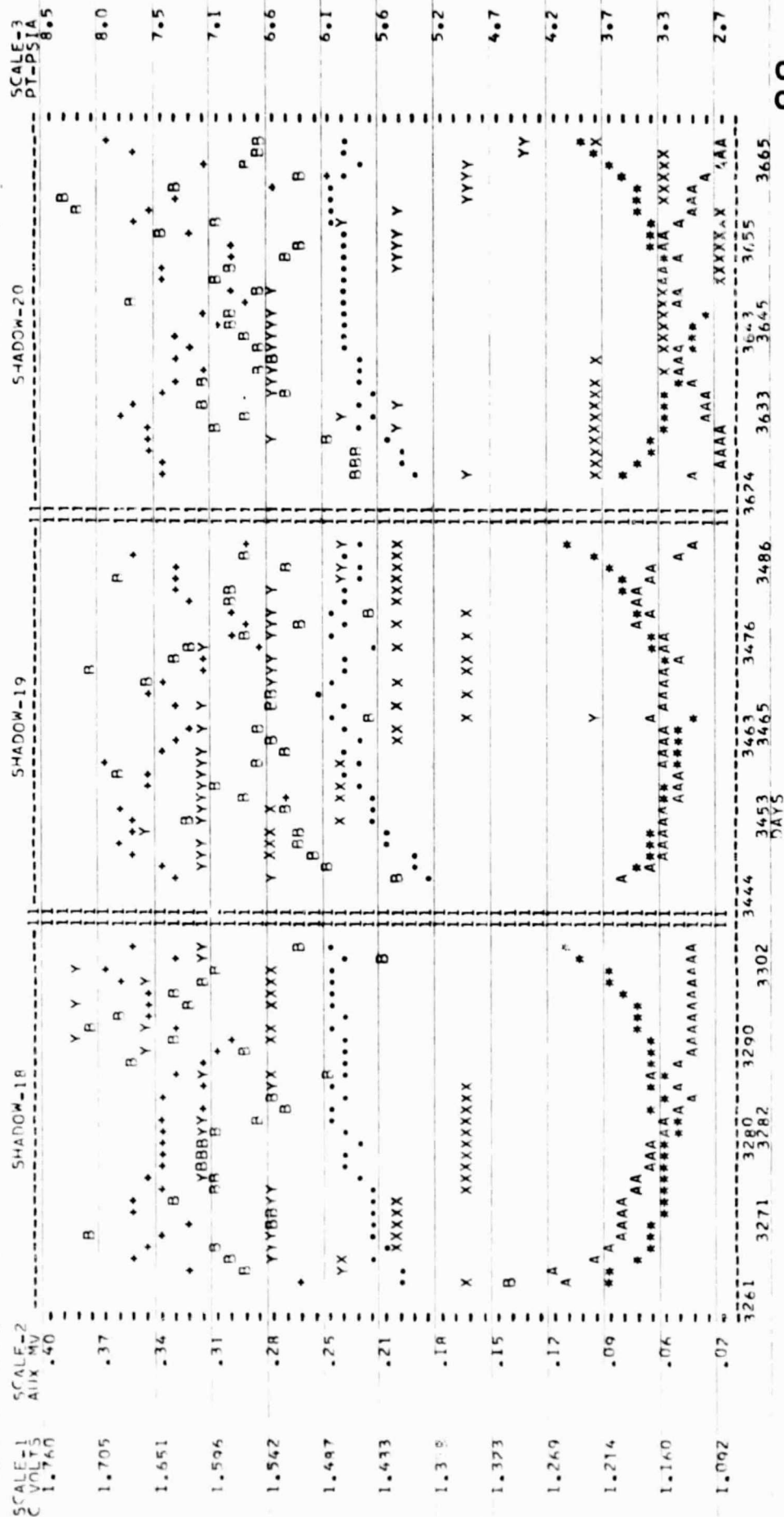
FIGURE 218

| | | | |
|----------------|--|--------------|-----------------------|
| KEY | | AVE | PID DISCHARGE VOLTAGE |
| * | | AVE | CFL VOLTAGE AT TRIP |
| * | | AVE | VOLTAGE AT FOC |
| * | | AVE AUX - | VOLT. AT FOC |
| * A X Y | | AVE AUX - | ELECT. TRANS. AT FOC |
| | | AVE PRESSURE | TRANS. |

ASYNCHRONOUS ORBIT LIBRATIONS

PACK = 209A

DEPTH DISCHARGE 60
TEMPERATURE 20
TEMPERF RATE 12
CATALOG 42B012AB
SERIAL 10-510-6,9-1
GENERAL ELECTRIC
PROJECT AYS F/G



ORIGINAL PAGE IS
OF POOR QUALITY

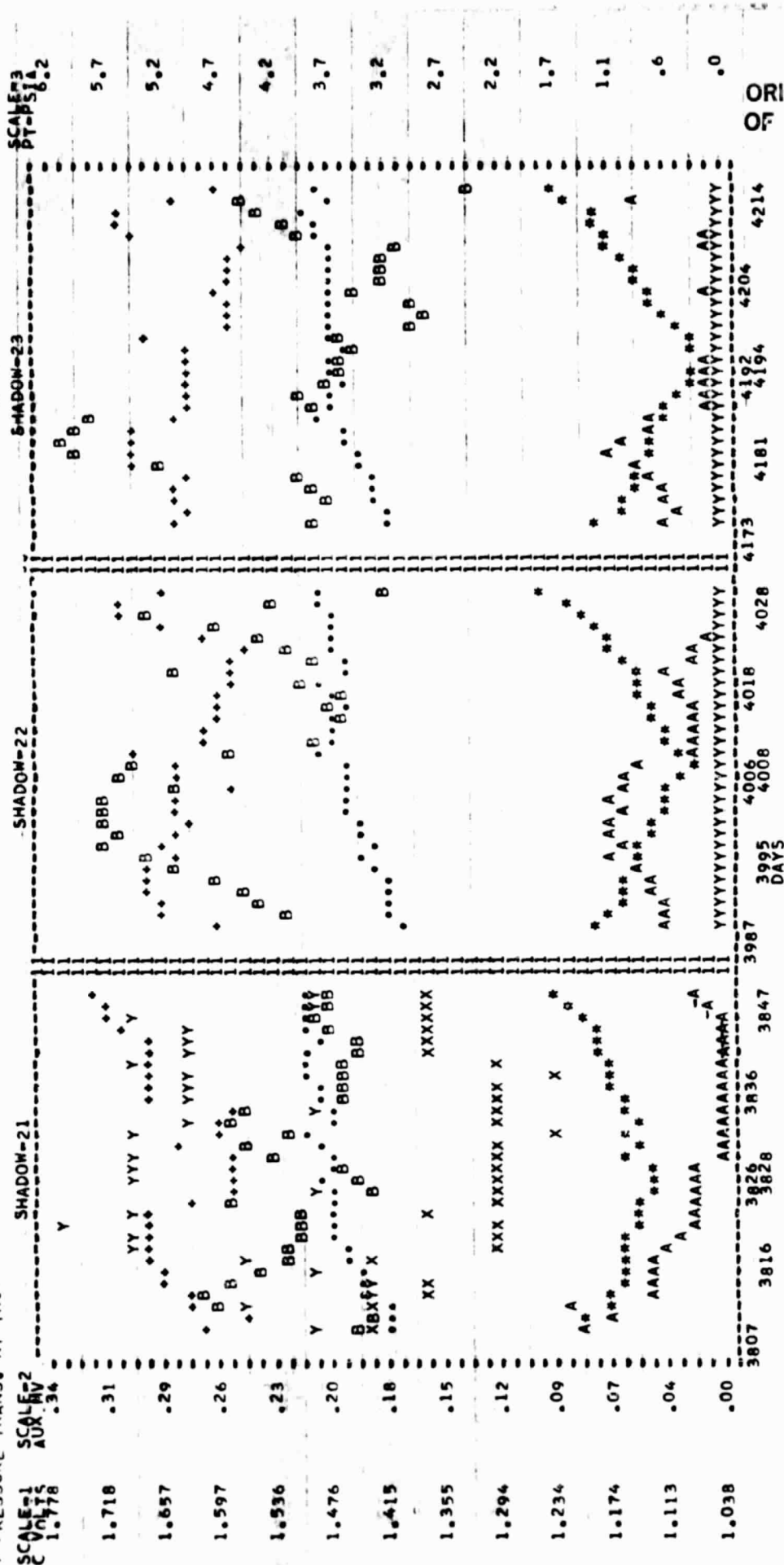
FIGURE 219

KEY
• • • A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
AVENUE AVENUE AVENUE AVENUE AVENUE AVENUE AVENUE AVENUE
END CELL AUX-SURE AVENUE AVENUE AVENUE AVENUE AVENUE AVENUE
DISCHARGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE
VOLTAGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE VOLTAGE

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 209A

DEPTH DISCHARGE 60-
TEMPERATURE 20
TEMPERATURE 22B
TEMPERATURE 10-6-9-8
TEMPERATURE 10-5-2-1
TEMPERATURE 10-5-2-1
TEMPERATURE 10-5-2-1



ORIGINAL PAGE IS
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FIGURE 220

KEY
 * AVE END DISCHARGE VOLTAGE
 * AVE CELL VOLTAGE AT TRIP
 * AVE CELL VOLTAGE AT EOC
 * AVE AUX-ELECT. VOLT. AT EOC
 * AVE AUX-ELECT. VOLT. AT TRIP
 * AVE AUX-ELECT. VOLT. AT EOC
 * AVE AUX-ELECT. VOLT. AT TRIP
 * AVE AUX-ELECT. VOLT. AT EOC
 * AVE AUX-ELECT. VOLT. AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 209A

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 CATALOG 42801288
 SERIAL 10-5-10-6-9-8-9-10-9-13
 GENERAL ELECTRIC CELLS
 PROJECT AYS F/G

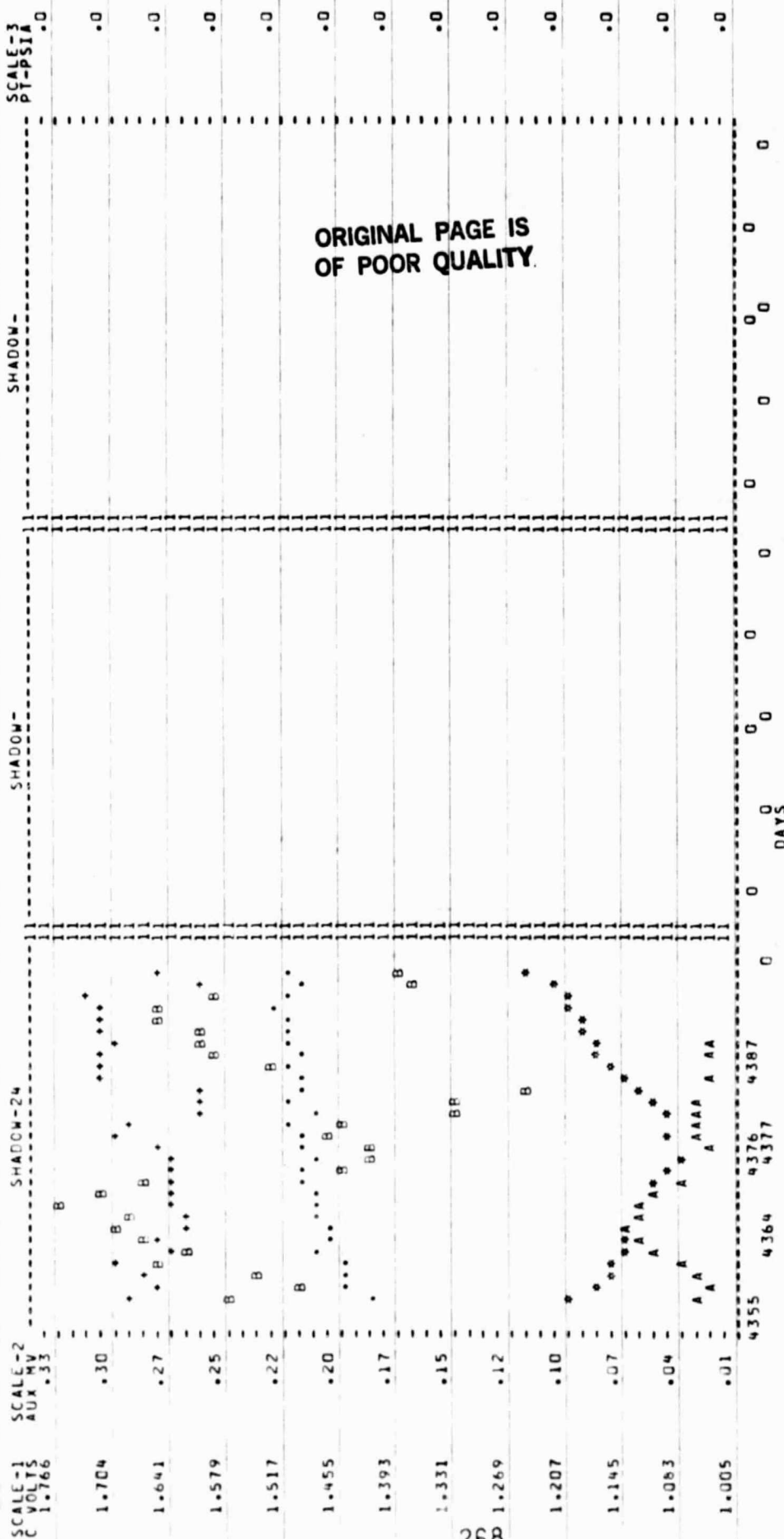


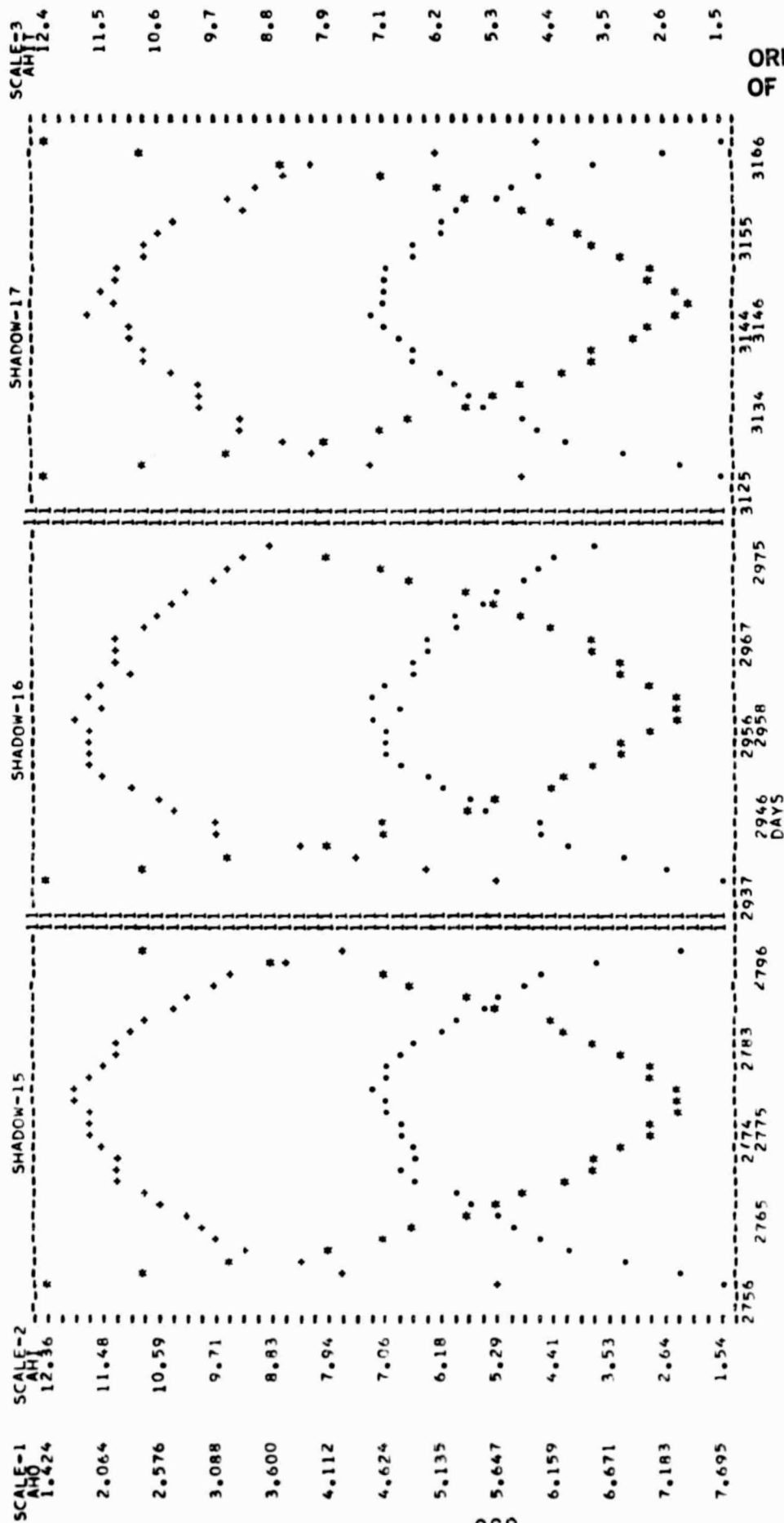
FIGURE 221

KEY
 * AHO
 * AHI-TOTAL
 * AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 209A

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 SERIAL LOG 428012AB
 SERIAL 10-9-8-9-10-9-13
 GENERAL ELECTRIC CELLS
 PROJECT AT5 F/G



ORIGINAL PAGE IS
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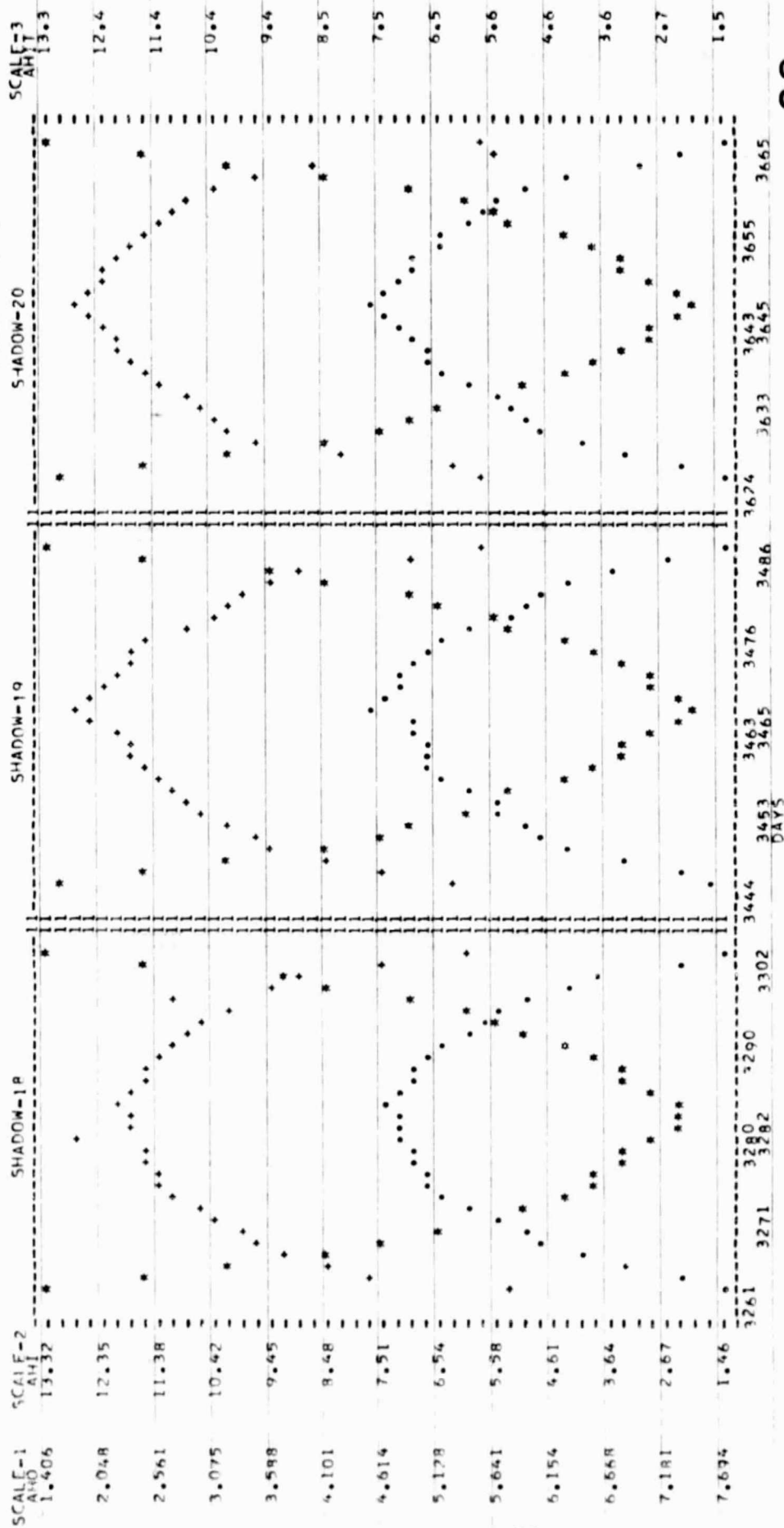
FIGURE 222

KEY
 * AHQ
 * AHQ-TOTAL
 * AHQ AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 209A

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 CATALOG 42R012AR
 SERIAL 10-5-10-8-9-10-9-13
 GENERAL ELECTRIC CELLS
 PROJECT AYS F/G



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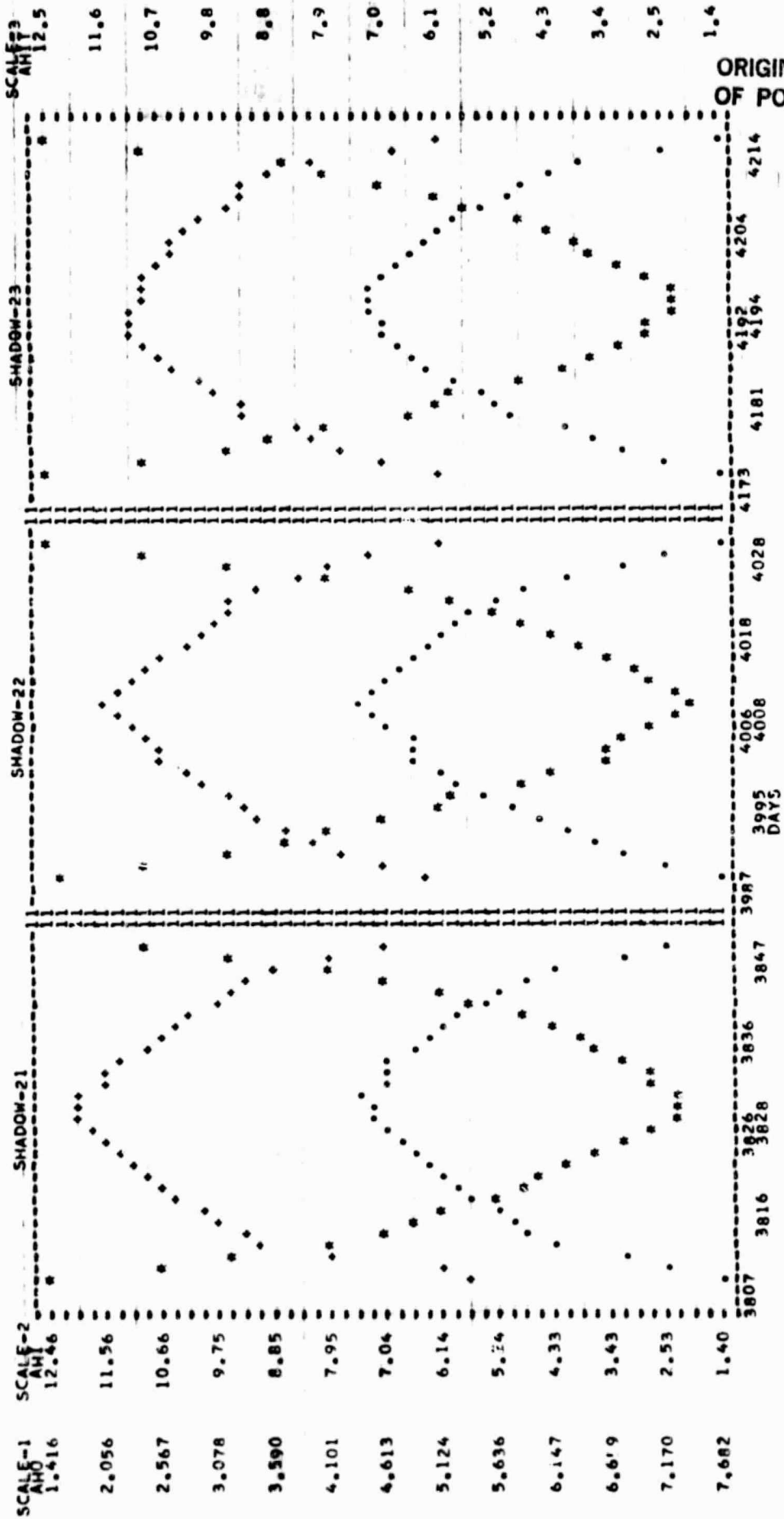
FIGURE 223

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 209A

KEY
 * AHO
 * AH1-TOTAL
 * AH1-10-9-13

DEPTH-DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 CATHODE LOG 420013AB
 GENERAL ELECTRIC
 PROJECT AYS F/G



ORIGINAL PAGE IS
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FIGURE 224

KEY
 * AHQ-TOTAL
 * AMI AT TRIP
 * AMI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 209A

DEPTH DISCHARGE 65
 TEMPERATURE 20
 AMPERE RATE 12
 CATALOG 428012AB
 SERIAL 10-510-6,9-8,9-10,9-13
 GENERAL ELECTRIC CELLS
 PROJECT AYS F/G

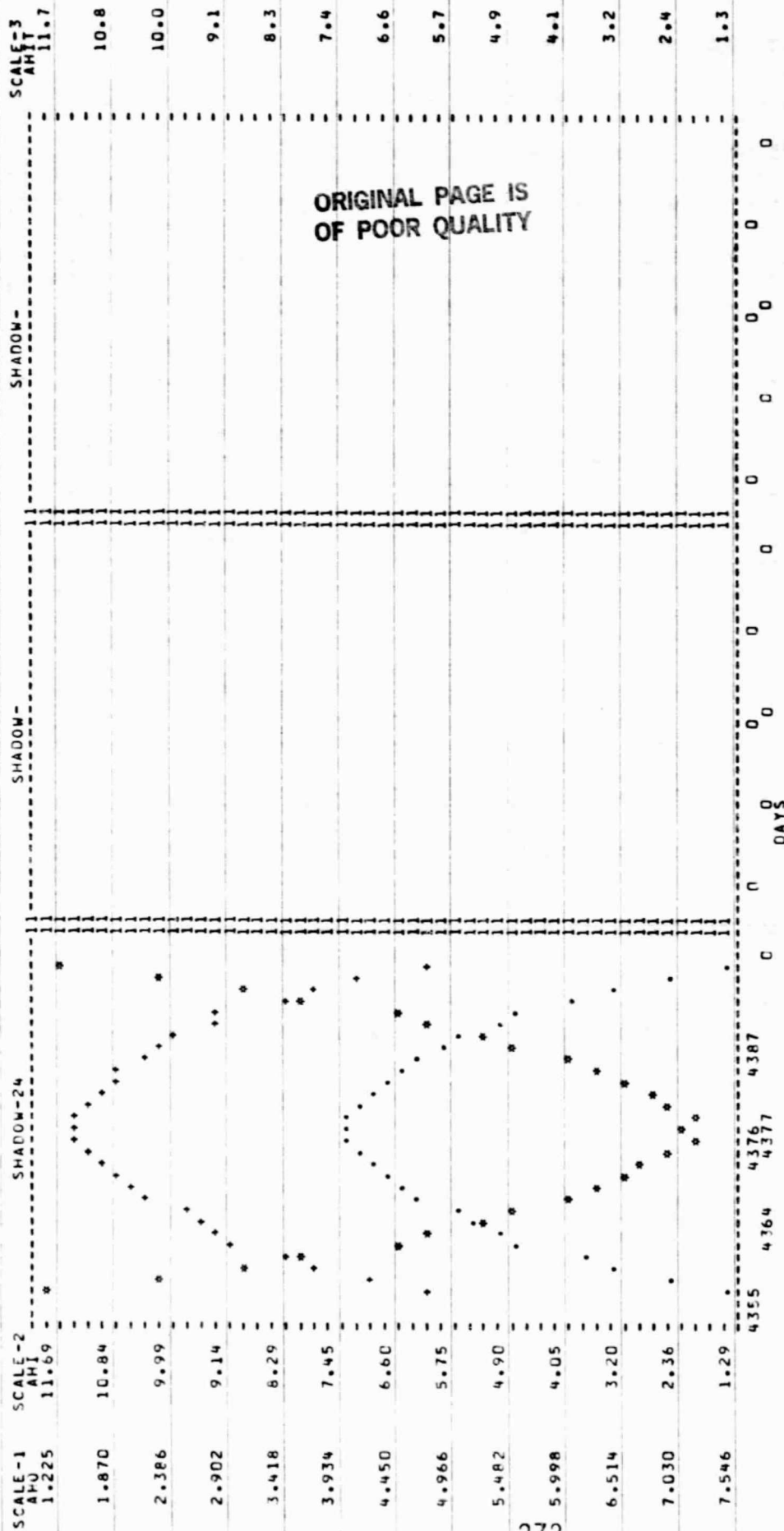


FIGURE 225

C-4

4. Pack 210A, 5-cells

a. Cell information: (Same as Pack 207A, Section V. C. 1.).

b. Parameters:

| | | | |
|--------------------------|-----|------------------------------|-----|
| Depth of Discharge (%) | 80 | Float/Trickle Current (amps) | .20 |
| Charge Control | AE | Auxiliary Electrode:* | |
| Charge Current (amps) | 3.0 | Resistance (ohms) | 300 |
| Discharge Current (amps) | 8.0 | Trip Voltage (mv) | 300 |
| Temperature (°C) | 20 | | |

*--Cells 1, 2 and 5.

c. Capacity checks: (Discharge to .50 volts any cell).

| | Cell
1 | Cell**
2 | Cell
3 | Cell**
4 | Cell
5 | ah
out |
|---------------------------|-----------|-------------|-----------|-------------|-----------|-----------|
| Shadow 5 | .541 | .979 | .869 | .905 | .303 | 13.80 |
| Shadow 6 | .635 | .989 | .902 | .876 | .161 | 13.46 |
| Shadow 7 | .828 | .997 | .954 | .920 | .452 | 12.98 |
| Shadow 8 | .946 | .996 | .980 | .952 | .499 | 13.36 |
| Shadow 9 | .338 | 1.133 | 1.130 | 1.093 | 1.100 | 10.22 |
| Shadow 10 | .263 | 1.193 | 1.193 | 1.190 | 1.185 | 6.02 |
| Shadow 11 | ** | .983 | .867 | .765 | -.080 | 11.80 |
| Shadow 12 | | .512 | 1.005 | .975 | -.205 | 12.16 |
| Shadow 13 | | .664 | 1.023 | .958 | .141 | 11.13 |
| Shadow 14 | | .585 | .971 | .685 | .412 | 12.04 |
| Shadow 15 (Figure 226) | | .505 | .972 | .494 | .529 | 11.81 |
| Shadow 16 (Figure 227) | | .475 | 1.013 | .248 | .587 | 11.19 |
| Shadow 17 (Figure 228) | | .465 | 1.073 | .783 | .830 | 9.92 |
| Shadow 18 (Figure 229) | | .427 | 1.125 | 1.004 | .935 | 8.93 |
| Shadow 19 (Figure 230) | | .408 | 1.025 | .439 | .817 | 9.81 |
| Shadow 20 (Figure 231) | | 9.17 | 1.018 | .439 | .824 | 9.57 |
| Shadow 21 (Figure 232) | | 9.17 | .986 | .283 | .736 | 10.60 |
| Shadow 22 (Figure 233) | | 8.40 | .701 | 9.28 | .433 | 11.44 |
| Shadow 23 (Figure 234) | | 7.10 | 11.72 | 11.09 | 9.81 | |
| Post Cycling (Figure 235) | | 6.69 | 12.99 | 11.80 | 8.93 | |

**--Cell 1 leaking, removed prior to shadow 11; low discharge voltage failures: cell 2 (day 3280, shadow 18) and cell 4 (day 3643, shadow 20); but cells allowed to continue cycling.

d. Test results during the Shadow Periods: (Figures 236 to 241)

(1) Cells 2 and 4 failed (below .50 volts during discharge) during shadows 18 and 20, respectively. The cells were allowed to continue cycling and cell 2 experienced cell reversal during shadows 22 and 23; but did not short. Cell 1 was removed from test prior to shadow 11 because it was leaking at the base of its fill tube due to its pressure assembly being bumped. This occurred prior to shadow 9 and the "drying out" of its components accounts for the erratic data obtained during shadows 9 and 10.

(2) Average End of Discharge Voltages: The reconditioning effect, due to the capacity checks, was evident for the first 16 shadows and shadows 21 and 22. The increase in voltages during the second half of shadows 17 to 20, must be attributed to the reconditioning effect of the daily discharges as the capacity removed during the capacity checks was approximately the same as that removed during the daily discharge prior to the capacity check.

(3) Average Cell Voltages at Trip and End of Charge: During the first 7 shadows, the voltages at trip were lower than those at the end of charge. During shadow 8, this condition began to reverse, and during the remaining shadows the voltages at trip were higher. High trip voltages at the beginning of each period appears to be due to the auxiliary electrodes becoming "desensitized" during the preceding sun period. This condition would last from 2 to 8 days for the first 11 shadows and then lasted throughout the remaining periods. The voltages at trip remained high as the cells were placed on trickle charge if a cell reached 1.65 volts regardless of the auxiliary electrode voltages. This value was changed to 1.60 volts on day 4012 of shadow 22. The end of charge voltages increased significantly, at the beginning and end of shadow 11, which was due to cell 2. These average voltages then steadily increased until shadow 16 when they began to stabilize as cell 2 went from having the highest to the lowest voltage at end of charge.

(4) The pack was discontinued in the middle of shadow 23 in which each cell was discharged to .50 volts.

(5) Post Cycling: Capacities of the two unfailed cells averaged 12.40 ampere-hours following a 3.0 ampere charge to 1.60 volts, any cell, at 20°C.

e. Performance during Sun Periods: The pack began test with a shadow period and therefore completed 22 sun periods. The pressures, cell 1, never exceeded 15 psia during any sun period prior to period 8 when its pressure assembly began leaking. Following is a listing of the high, average and low cell voltages at the start and end of sun periods 15 through 22.

| Sun Periods | | | | | | | | | | | | |
|-------------|--|--|----------|----------|----------|----------|----------|----------|----------|------------|--|--|
| | | | 15 | | 16 | | 17 | | 18 | | | |
| Voltages*** | | | Start | End | Start | End | Start | End | Start | End | | |
| High | | | 1.615(5) | 1.399(4) | 1.570(5) | 1.398(5) | 1.576(5) | 1.419(5) | 1.545(5) | 1.451(5) | | |
| Average | | | 1.528 | 1.389 | 1.497 | 1.383 | 1.505 | 1.386 | 1.455 | 1.399 | | |
| Low | | | 1.464(4) | 1.381(3) | 1.429(3) | 1.366(3) | 1.407(2) | 1.350(2) | 1.399(2) | 1.379(2,3) | | |
| | | | 19 | | 20 | | 21 | | 22 | | | |
| Voltages | | | Start | End | Start | End | Start | End | Start | End | | |
| High | | | 1.549(5) | 1.553(5) | 1.567(4) | 1.532(5) | 1.541(4) | 1.532(5) | 1.543(4) | 1.523(5) | | |
| Average | | | 1.515 | 1.406 | 1.499 | 1.427 | 1.477 | 1.404 | 1.493 | 1.418 | | |
| Low | | | 1.468(3) | 1.345(2) | 1.415(3) | 1.379(3) | 1.391(3) | 1.347(2) | 1.427(3) | 1.350(2) | | |

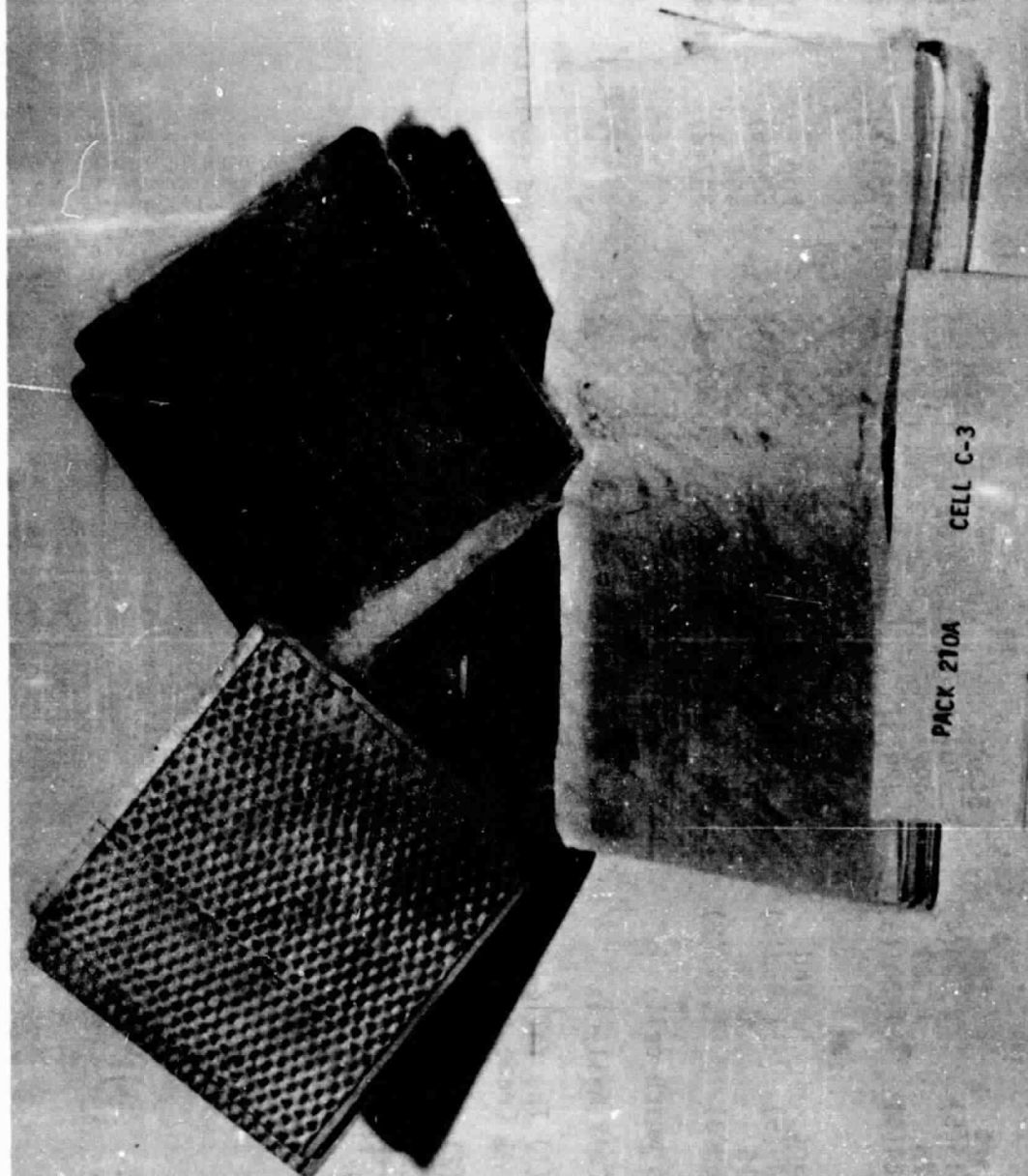
***--() indicates which cell.

f. Cell Analysis:

(1) The following photograph shows the condition of the plates and separator of cell 3, as it was opened at Crane following completion of 22.5 shadow periods.

(2) Cells 1, 2, 4 and 5 were returned to GSFC.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



Pack 210A, Cell 3, 22.5 shadow periods
at 80 percent DOD, 20°C: Cell was damp
with extreme migration, as evidenced
by separator adhering to negative plate.

PHOTOGRAPH 3

276

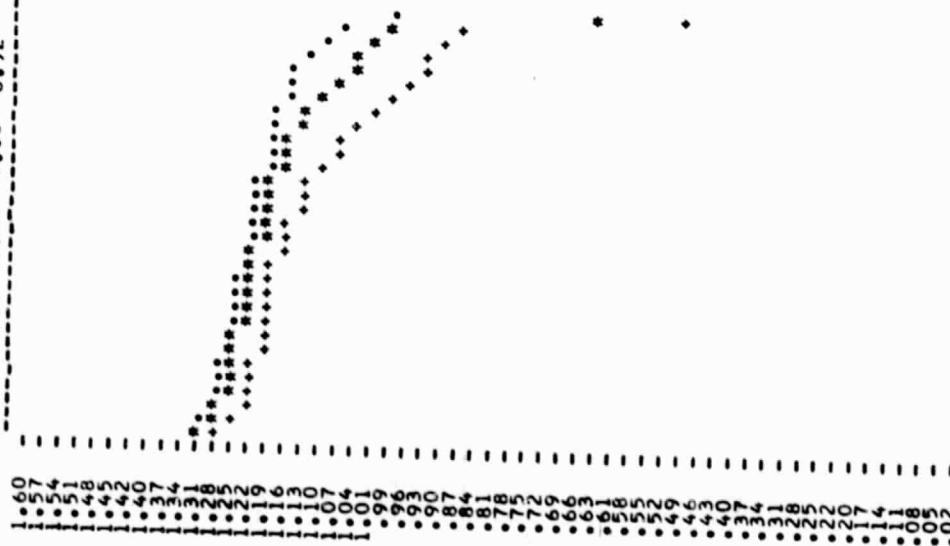
PACK NUMBER IS 210A
 SHADOW PERIOD IS 15
 CYCLE NUMBER IS 2776.
 DISCHARGE RATE IS 8.

KEY
 : HIGH CELL
 * LOW CELL
 # AVERAGE

AMPERE HOUR OUT

32 2.22 4.13 6.05 7.96 11.81
 1.27 3.18 5.09 7.00 8.92

C
A
P
A
C
I
T
Y
C
E
L
L
V
O
L
T
A
G
E
S
C
A
L
E



1. 9. 16. 23. 30. 37. 46. 52. 59. 66. 73.

TIME IN MINUTES
 CELLS INCLUDED V2 V3 V4 V5

FIGURE 226

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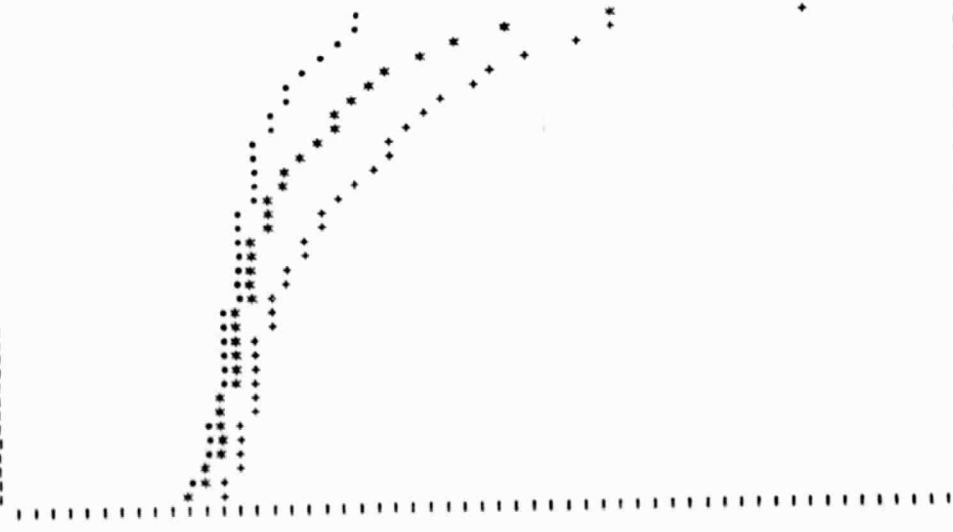
BACK NUMBER IS 131VA
CYCLE NUMBER IS 2957.
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY HIGH CELL
+ LOW CELL
* AVERAGE

32 2.24 4.15 6.08 7.99 9.91 11.19
1.28 3.20 5.11 7.04 8.95 10.87

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 16. 23. 30. 37. 44. 52. 59. 66. 73. 81. 83.
TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4

FIGURE 227

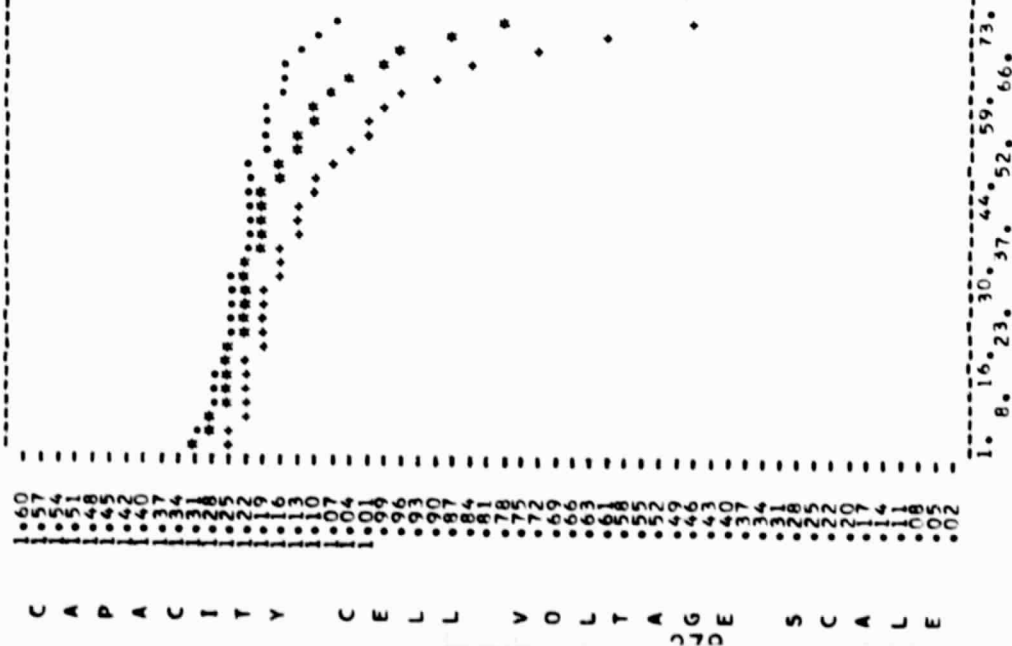
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 210A
 SHADOW PERIOD IS 17
 CYCLE NUMBER IS 3145
 DISCHARGE RATE IS 8.

WQEC/C 81-120A

32 2.24 4.16 6.08 8.00 9.92
 1.28 3.20 5.12 7.04 8.96

AMPERE HOUR OUT



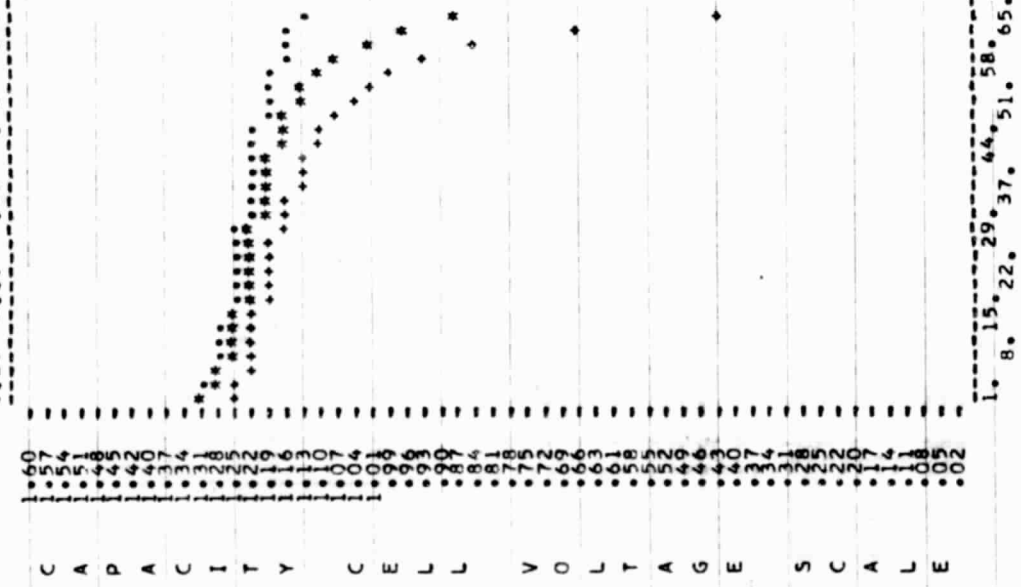
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FIGURE 228

PACK NUMBER IS 210A
SHADOW PERIOD IS 18
CYCLE NUMBER IS 03281
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE



ORIGINAL PAGE IS
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TIME IN MINUTES V-2 V-3 V-4 V-5
CELLS INCLUDED

FIGURE 229

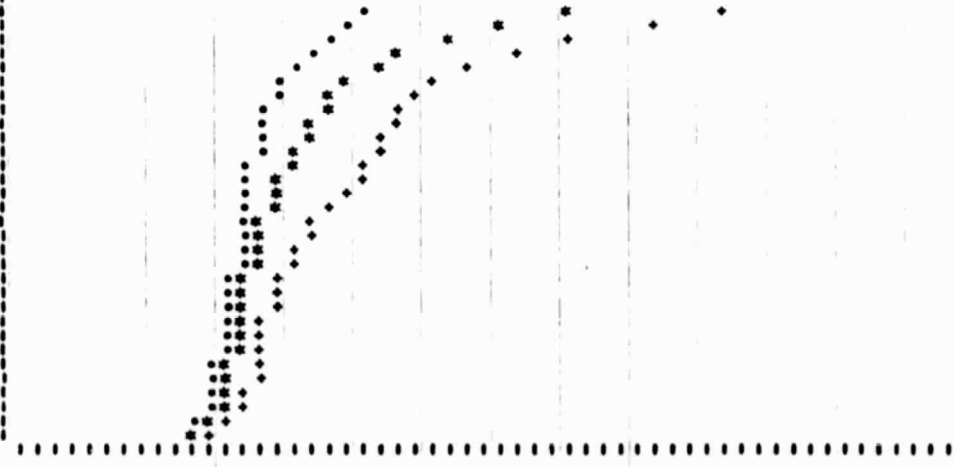
KEY
 * HIGH CELL
 : LOW CELL
 . AVERAGE

PACK NUMBER IS 210A
 SHADOW PERIOD IS 19
 CYCLE NUMBER IS 3464
 DISCHARGE RATE IS 8.

AMPERE HOUR OUT

23 2.15 4.06 5.98 7.89 9.81
 1.19 3.11 5.02 6.94 8.85

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 22. 29. 37. 44. 51. 58. 65. 73.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 230

ORIGINAL PAGE IS
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PACK NUMBER IS 210A
SHADOW PERIOD IS 20
CYCLE NUMBER IS 3644
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

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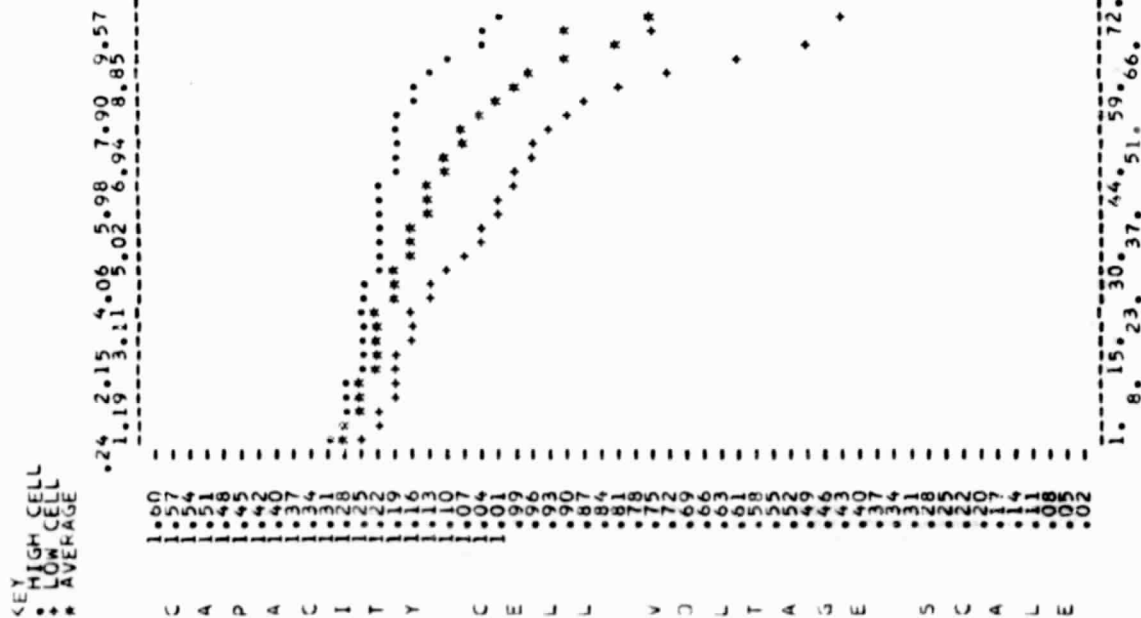


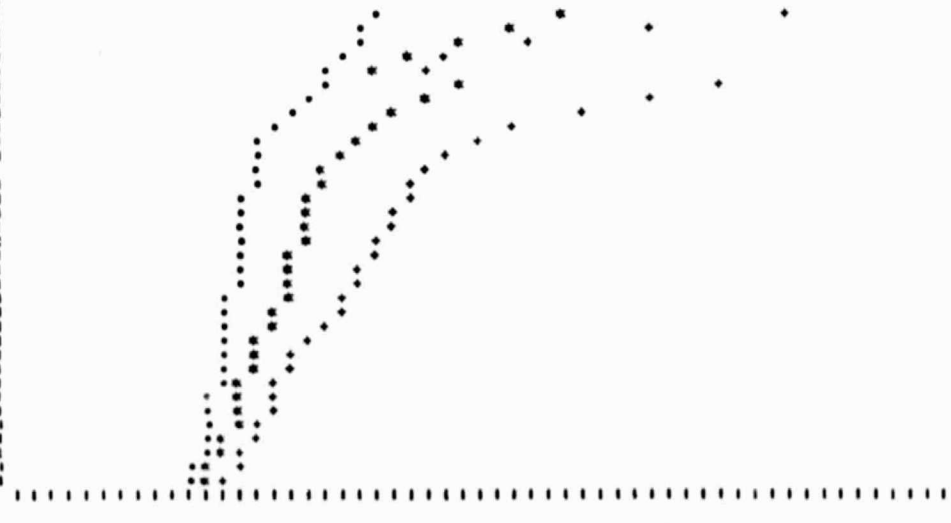
FIGURE 231

PACK NUMBER IS 210A
SHADOW PERIOD IS 21
CYCLE NUMBER IS 3827
DISCHARGE RATE IS 8.
AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

23 2.15 4.06 5.97 7.89 9.64
1.19 3.10 5.02 6.93 8.84 10.60

C
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A
L
E



1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81.

TIME IN MINUTES
CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 232

ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 2104
 SHADOW PERIOD IS 22
 CYCLE NUMBER IS 4007
 DISCHARGE RATE IS 8.

AMPERE HOUR OUT

ORIGINAL PAGE IS
 OF 2 QUALITY

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

08 2.00 3.92 5.84 7.76 9.68 11.44
 1.04 2.96 4.88 6.80 8.72 10.64

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

C A T A C I T Y C E L L V O L T A G E S C A L E

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 233

KEY
 • HIGH CELL
 ♦ LOW CELL
 ■ AVERAGE

AMPERE HOUR OUT

21.11.1

| | | | | | |
|------|------|------|------|------|-------|
| 1.03 | 2.95 | 4.86 | 6.78 | 8.53 | 10.45 |
|------|------|------|------|------|-------|

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| 60 | C | 57 | C | 54 | C | 51 | C | 48 | P | 45 | A | 42 | A | 39 | C | 36 | C | 33 | I | 30 | I | 27 | T | 24 | Y | 21 | Y | 18 | C | 15 | C | 12 | O | 9 | A | 6 | O | 3 | O | 0 | I | | | | | |
| 60 | | 57 | | 54 | | 51 | | 48 | | 45 | | 42 | | 39 | | 36 | | 33 | | 30 | | 27 | | 24 | | 21 | | 18 | | 15 | | 12 | | 9 | | 6 | | 3 | | 0 | | -3 | | -6 | | -9 |

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| | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|-----|
| 1. | 16. | 30. | 45. | 59. | 73. | 88. | 90. |
| 9. | 23. | 37. | 52. | 66. | 82. | | |

| CELLS | TIME IN MINUTES | | | | |
|-------|-----------------|-----|-----|-----|-----|
| | INCLUDED | V-2 | V-3 | V-4 | V-5 |
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| 84 | | | | | |
| 85 | | | | | |
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| 97 | | | | | |
| 98 | | | | | |
| 99 | | | | | |
| 100 | | | | | |

FIGURE 234

PACK NUMBER IS 210A
POST CYCLING
CYCLE NUMBER IS 4194
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

31 2.23 4.14 6.05 7.97 9.88 11.80 12.99
27 3.19 5.10 7.01 8.93 10.84 12.67

C 0.1
A 1.5
P 1.4
A 1.4
C 1.3
I 1.2
T 1.2
Y 1.1
C 1.0
E 0.9
L 0.8
J 0.7
V 0.6
C 0.5
J 0.4
T 0.3
A 0.2
S 0.1
C 0.0
A 0.0
L 0.0
E 0.0

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TIME IN MINUTES
CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 235

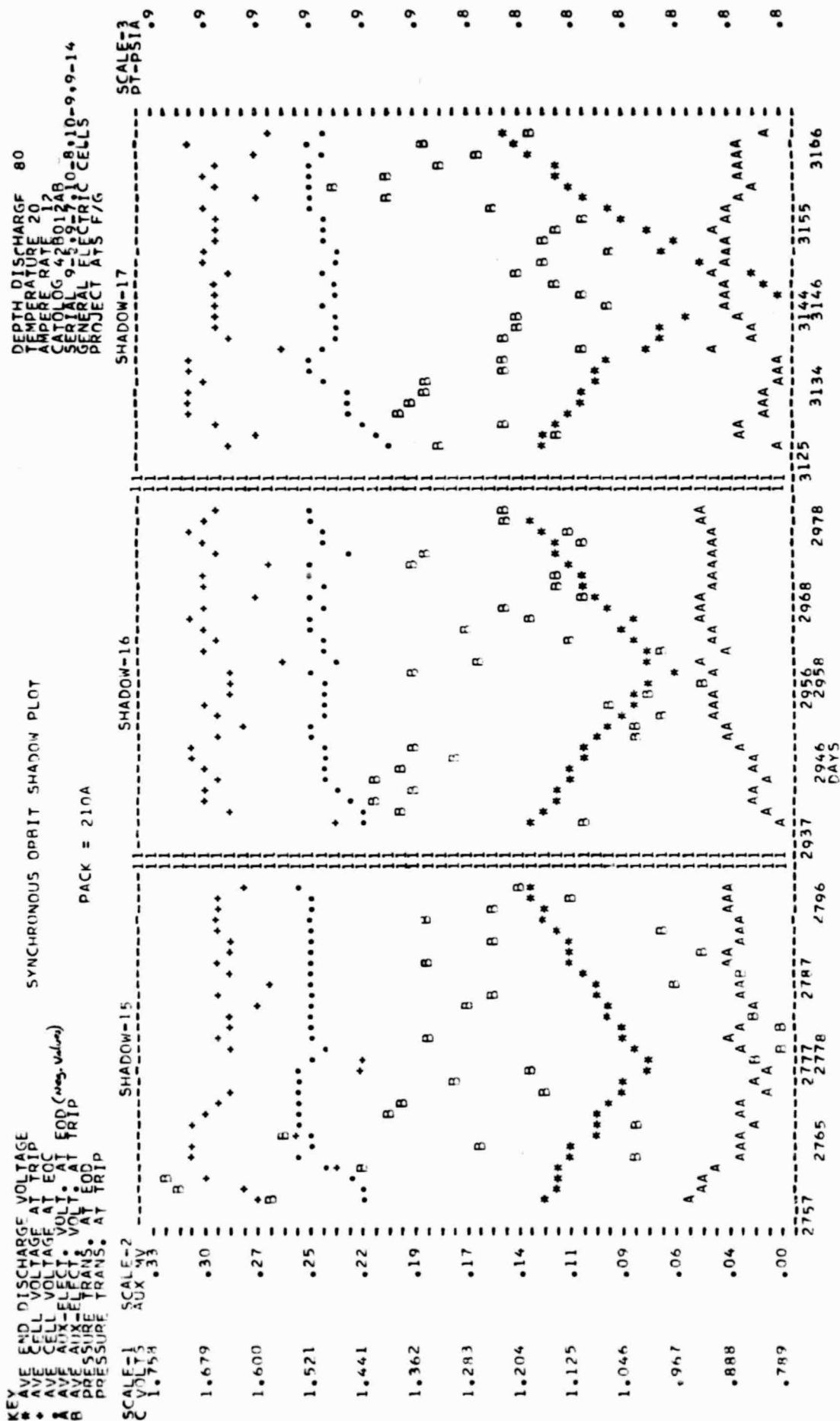


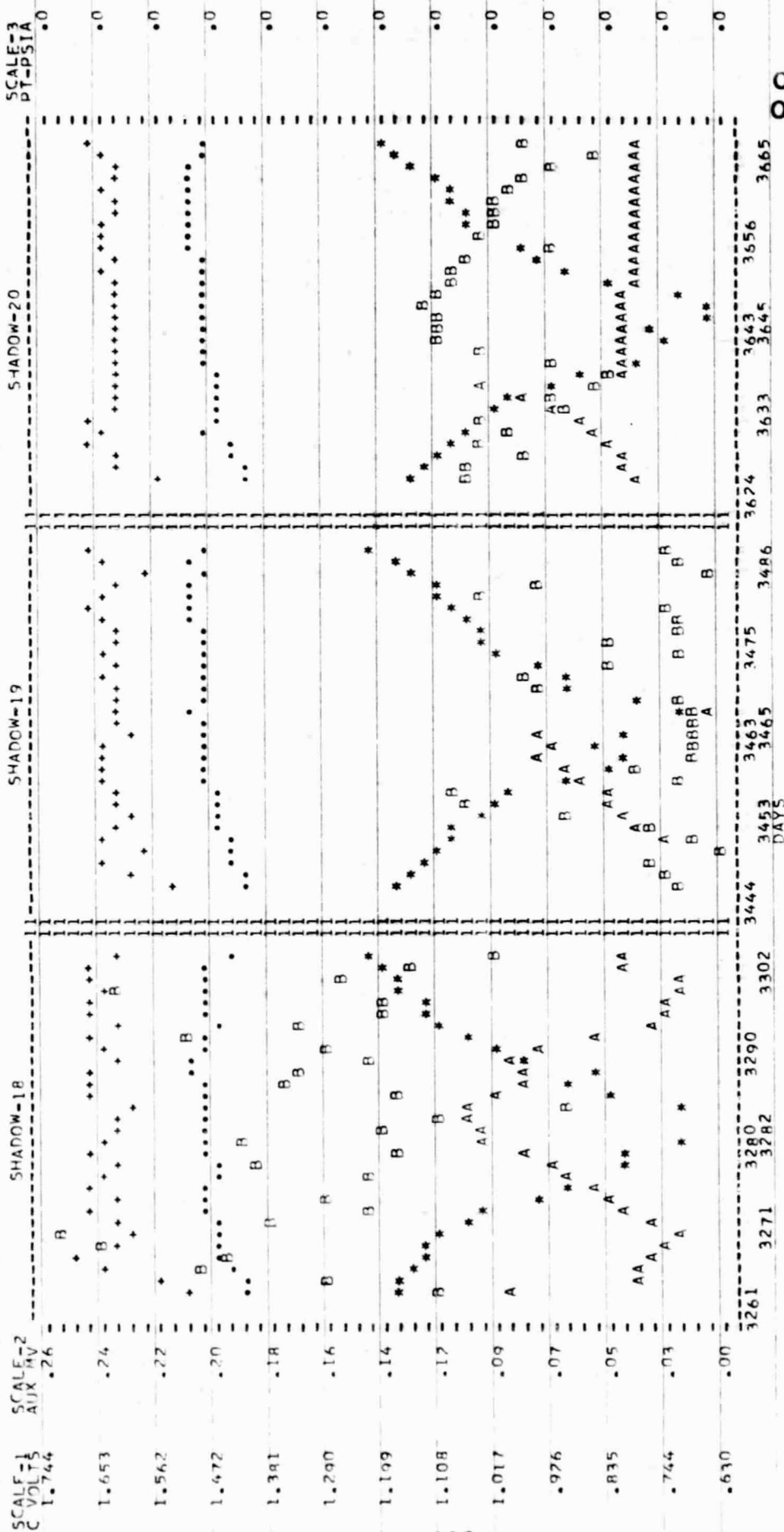
FIGURE 236

KEY
 * AVE END DISCHARGE VOLTAGE
 + AVE CELL VOLTAGE AT TDP
 A AVE CELL VOLTAGE AT EOC
 H AVE AUX-ELECT. VOLT. AT EOC
 PRESSURE TRANS. AT EOC
 PRESSURE TRANS. AT TRIP

SYNCHRONOUS OPRT SHADOW PLOT

PACK = 210A

DEPTH DISCHARGE 80
 TEMPERATURE 20
 AMPERE RATE 12
 CATALOG 42R012AB
 SERIAL 9-5-9-7:10-8,10-9,9-14
 GENERAL ELECTRIC CELLS
 PROJECT AYS F/G



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Cell Failures - Low Discharge Voltage:
 Cell 2 - Day 3280
 Cell 4 - Day 3643

FIGURE 237

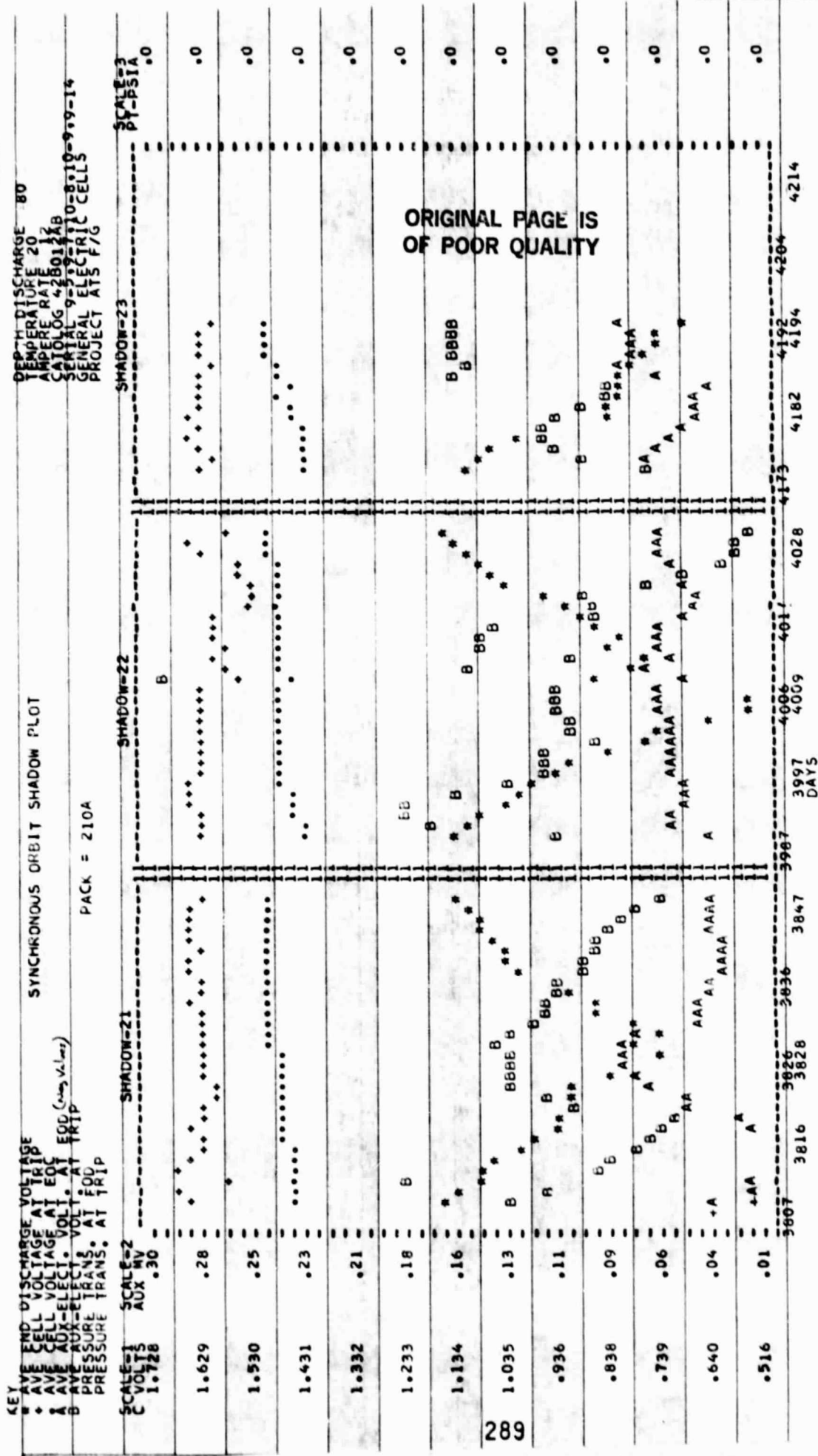


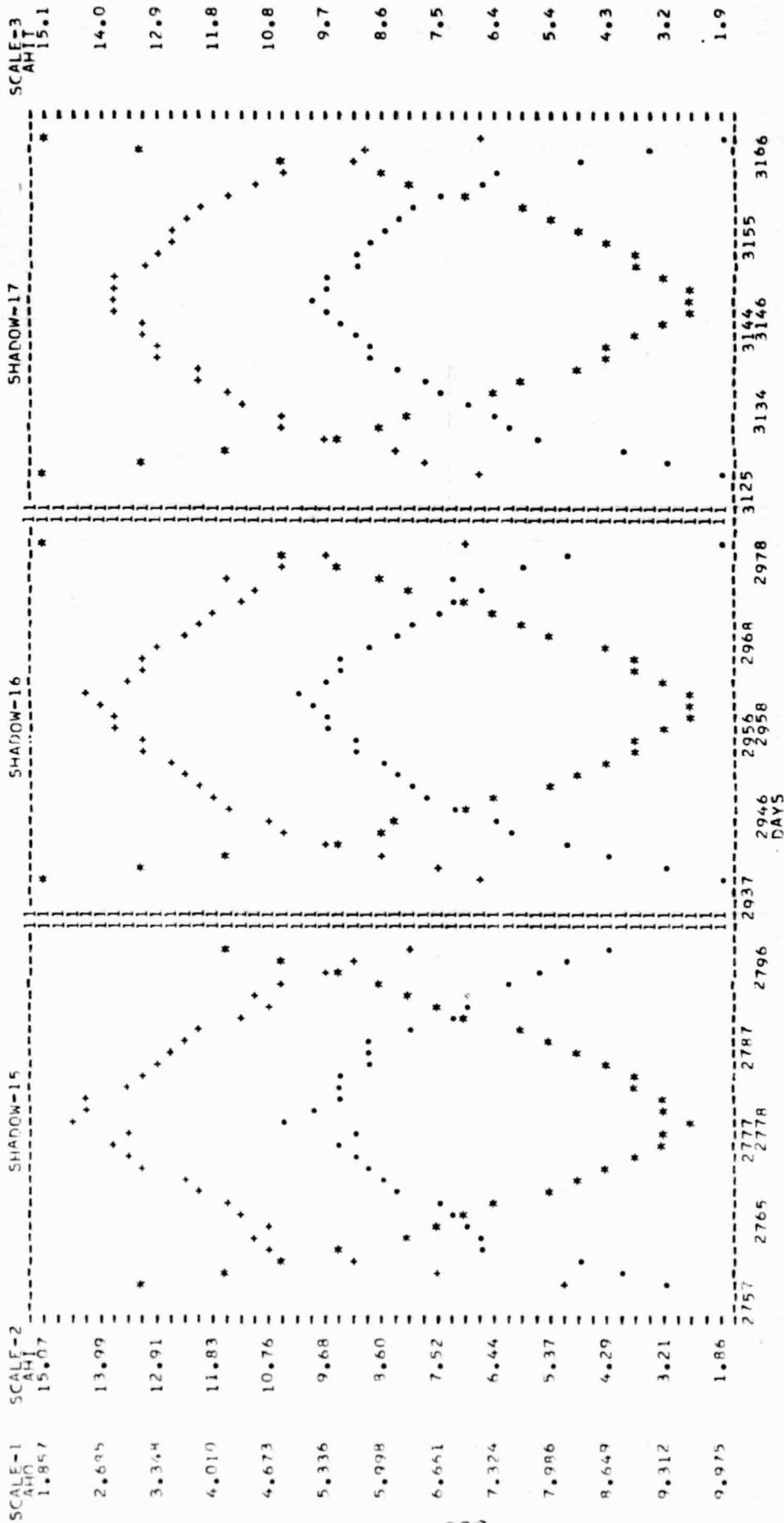
FIGURE 238

KEY
 * AHO
 + AHI-TOTAL
 . AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 210A

DEPTH DISCHARGE 80
 TEMPERATURE 20
 AMPERE RATE 12
 CATHODE LOG 428012AR
 SERIAL 9-5-9-10-8-10-9-9-14
 GENERAL ELECTRIC CELLS
 PROJECT ATTS F/G



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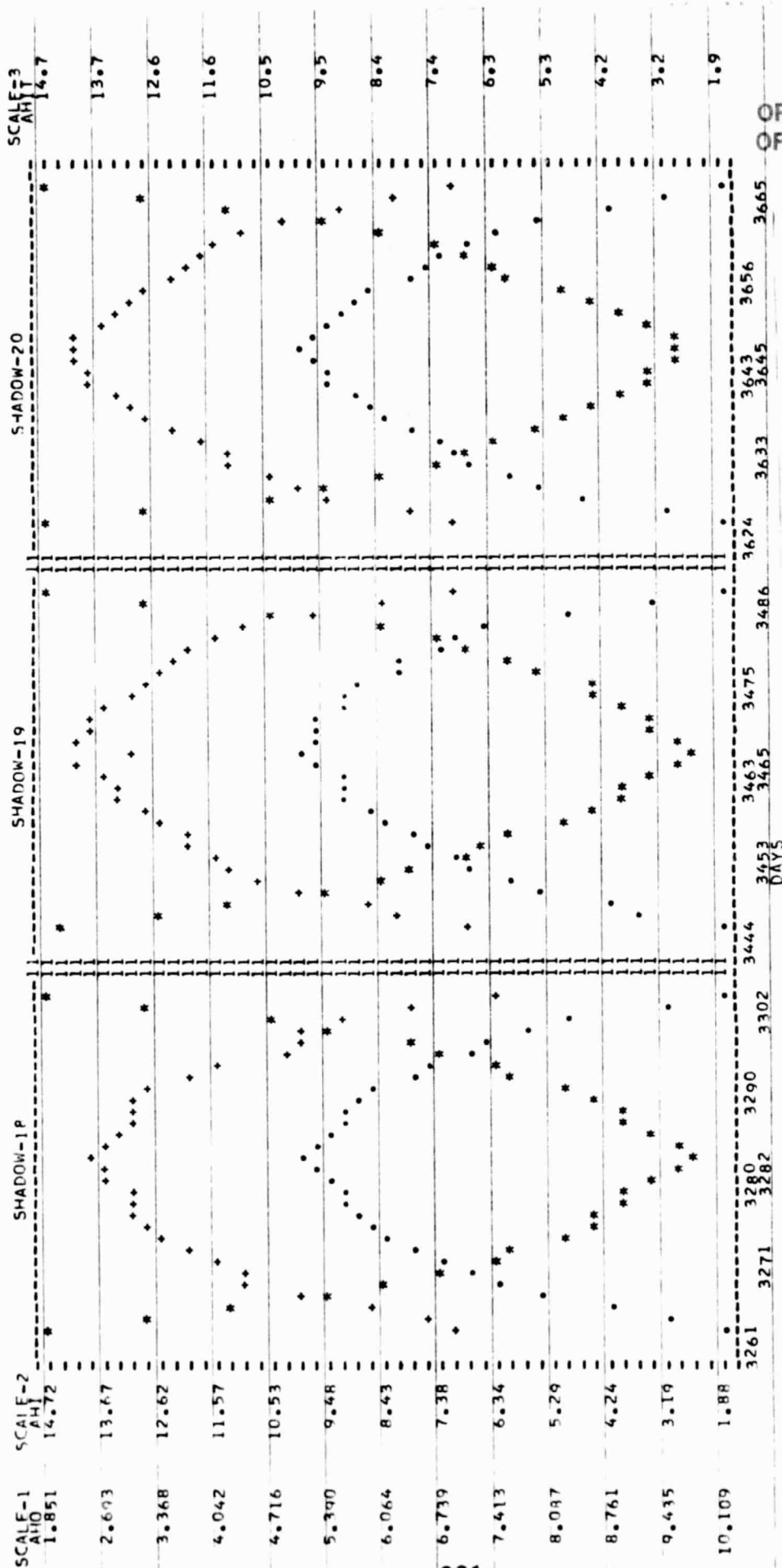
FIGURE 239

KEY
 * AHO
 + AHI-TOTAL
 • AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 80
 TEMPERATURE 20
 AMPERE RATE 12
 CATALOG 42B012AB
 SERIAL 9-5-9-7-10-8-10-9-9-14
 GENERAL ELECTRIC CELLS
 PROJECT AT5 F/C

PACK = 210A



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FIGURE 240

KEY

* AHI - TOTAL
+ AHI AT TRIP
• AHI AT TRIP

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 80
TEMPERATURE 20
AMPERE RATE 12
CATALOG 42 B012 AB
SERIAL 9-3-97, 10-8, 10-9, 9-14
GENERAL ELECTRIC CELLS
PROJECT ATS F/G

PACK = 210A

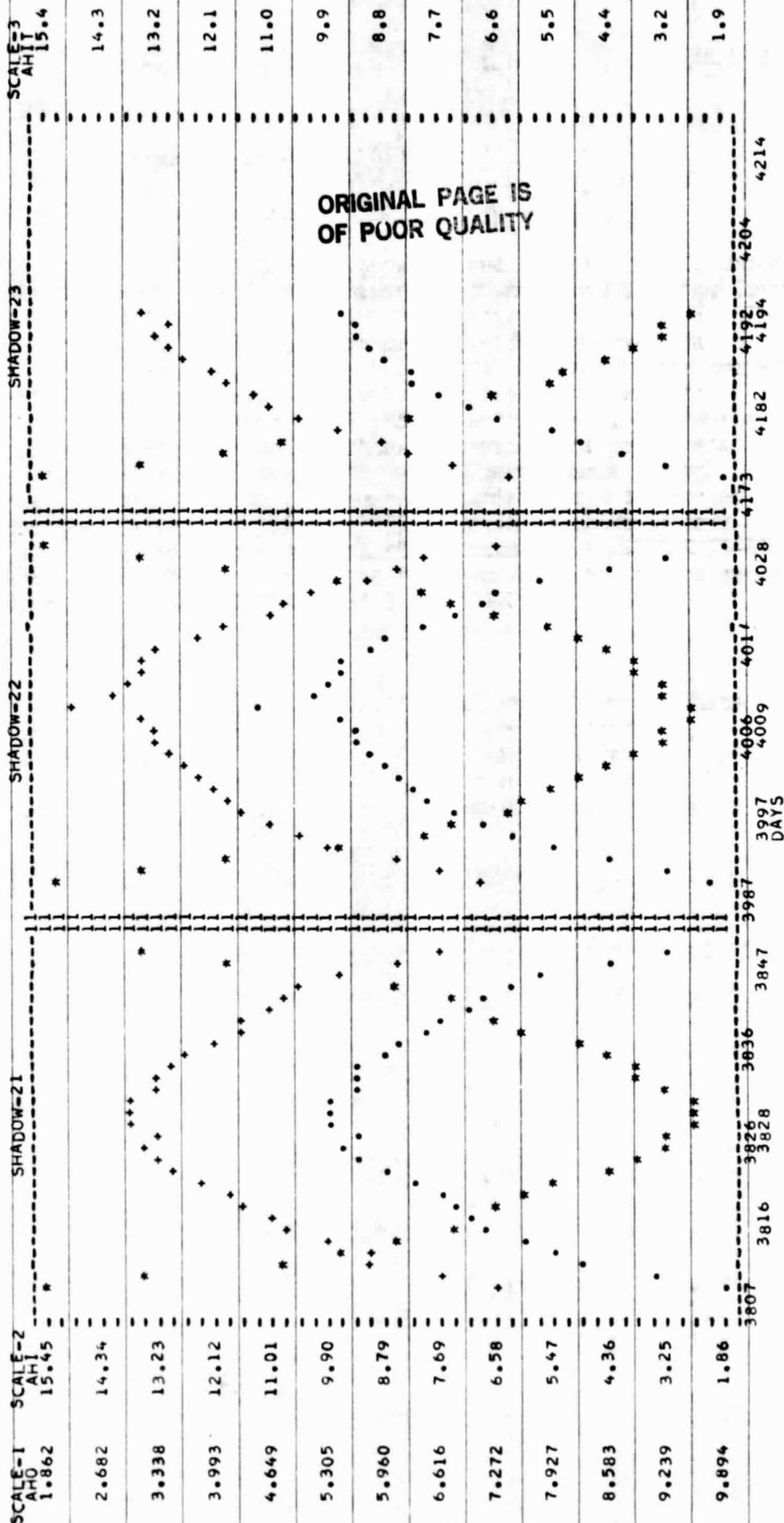


FIGURE 241

5. Pack 211A, 5-cells

a. Cell information: (Same as Pack 207A, Section V. F. 1.).
This pack was tested at 40°C, with a depth of discharge of 60 percent.
The pack was discontinued following shadow period 5.

6. Pack 212A, 5-cells

a. Cell information: (Same as Pack 207A, Section V. F. 1.).
This pack was tested at -20°C, with a depth of discharge of 80 percent.
The pack was discontinued following shadow period 11.

G. GE 12.0 ah (IUE)

1. Pack 228A, 5-cells

a. Cell information:

(1) The cells were manufactured for NASA, GSFC, under NASA contract number NAS-5-19584, according to the Manufacturing Control Document (MCD) 232A2222AA-54 and GSFC's specification S-761-P-6. The cells are from a lot of 175 cells procured for the International Ultraviolet Explorer (IUE) Project; but due to a change in the project requirements, were not used. The cells were identified with the manufacturer's catalog number 42B012AB21-G2 with three cells having auxiliary electrodes and four cells having pressure gauges. Details of cell design, construction, manufacturing and performance during acceptance testing by the manufacturer are summarized and reported in GSFC report X-711-16-13 of January 1976. Initial evaluation test results are contained in the NAVWPNSUPPCEN Crane Report WQEC/C 76-89 of 15 March 1976. The results of the first eclipse season were reported in the Crane Report WQEC/C 77-134 of 9 June 1977.

b. Parameters:

| | | | |
|--------------------------|-------|------------------------------|-----|
| Depth of Discharge (%) | 80 | Float/Trickle Current (amps) | .20 |
| Charge Control | AE/VL | Auxiliary Electrode*: | |
| Charge Current (amps) | 1.2 | Resistance (ohms) | 300 |
| Discharge Current (amps) | 8.0 | Trip Voltage (mv) | 150 |
| Temperature (°C) | 20 | Bandwidth (mv) | 30 |
| Voltage Limit (v/c) | 1.48 | | |

*--Cells 1, 3 and 5

c. Capacity Checks: (Discharge each cell to .75 volts)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Precycling | .575 | .189 | 1.171 | .188 | 1.204 | 11.23 |
| Shadow 1 | | | | | .198 | 15.78 |
| Shadow 2 (Figure 242)** | | | | .965 | .189 | 15.47 |
| Shadow 3 (Figure 243) | | | | | 13.79 | |
| Shadow 4 (Figure 244) | | | 15.77 | 14.79 | 13.97 | |
| Shadow 5 (Figure 245) | | | | | 11.52 | |
| Shadow 6 (Figure 246) | | | | 13.28 | 12.70 | |
| Shadow 7 (Figure 247) | | | | | 13.06 | |
| Shadow 8 (Figure 248) | | | 13.86 | 13.69 | 13.36 | |
| Shadow 9 (Figure 249) | | | | | 13.41 | |
| Shadow 10 (Figure 250) | | | | 14.32 | 14.32 | |
| Shadow 11 (Figure 251) | | | | | 14.16 | |

**--Discharge till any cell reaches .75 volts.

d. Test results during the Shadow Periods: (Figures 252 to 257)

(1) End of Discharge Voltages: The reconditioning effect, due to the capacity check, can be seen for each shadow period, in which the greatest effect is seen when 3 cells were capacity checked. The decrease in voltages is due to those cells on open circuit for 24 hours during the other cells capacity checks. During the last four shadows, the reconditioning effect, is not noticeable after 9 to 11 days, when comparing EOD voltages. The reconditioning effect, from one shadow to another, is only noticeable 2 to 3 days prior to the next shadow's capacity check. There is a significant drop in voltages from shadow 1 to shadow 2 and shadow 2 to shadow 3; but this is seen as a characteristic of these cells. This is validated by the capacity obtained during shadow 4 in which 7.0 ah of cell 3's capacity was available below 1.10 volts. There was an increase in the EOD voltages during shadow 10 due to the control unit not cutting the current back after the auxiliary trip voltage was reached.

(2) Capacity checks: The low value (11.52 ah) obtained during shadow 5 may have been due to the previous charge time being 17.8 hours instead of 22.8 hours which decreased the input by 2.0 ah. Cell 5, which is capacity checked each shadow, has shown the greatest loss in capacity; but has the least voltage degradation of those cells which receive capacity checks. Its percent of total capacity to 1.10 and 1.00 volts was 73 and 89 during its last capacity check. There was an increase in capacity after shadow 5 and this is due to the control unit not reducing the current to a low level when the auxiliary trip was reached, which resulted in an increase in the ampere-hour input.

(3) Pressure at End of Discharge and Charge: The pressures have remained below 30 PSIA throughout the shadow periods.

e. Performance during Sun Periods: Pack has completed 10 sun periods as it began test with a shadow period. The pressures have not exceeded 20 psia during these periods. Following is a listing of the high, average, and low cell voltages at the start and end of each sun period.

| Sun Periods | | | | | | | | | | |
|--------------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| <u>Voltages***</u> | | | | | | | | | | |
| High | Start
1.416(1) | End
1.407(1) | Start
1.413(1) | End
1.416(1) | Start
1.413(1) | End
1.416(1) | Start
1.405(1) | End
1.413(1) | Start
1.395(1) | End
1.399(1) |
| Average | 1.413 | 1.405 | 1.410 | 1.413 | 1.410 | 1.413 | 1.401 | 1.411 | 1.393 | 1.396 |
| Low | 1.411(2) | 1.403(4) | 1.406(4) | 1.409(4) | 1.406(4) | 1.409(4) | 1.399(4,5) | 1.410(2,4,5) | 1.390(4) | 1.394(4) |
| <u>Voltages</u> | | | | | | | | | | |
| High | Start+
1.393(1) | End
1.399(1) | Start
1.400(1) | End
1.405(1) | Start
1.397 | End
1.403 | Start
1.398(1) | End
1.405(1) | Start
1.397(1) | End
1.415(1) |
| Average | 1.391 | 1.397 | 1.397 | 1.403 | 1.397 | 1.403 | 1.396 | 1.402 | 1.395 | 1.411 |
| Low | 1.389(4) | 1.395(3,4) | 1.394(4) | 1.400(4) | 1.394(4) | 1.400(4) | 1.394(4,5) | 1.400(4) | 1.393(3,5) | 1.409(4) |
| <u>Voltages</u> | | | | | | | | | | |
| High | Start
1.402(1,2) | End
1.411(1) | Start
1.403(1,2) | End
1.420(1) | Start
1.403(1,2) | End
1.420(1) | Start
1.403(1,2) | End
1.420(1) | Start
1.403(1,2) | End
1.420(1) |
| Average | 1.400 | 1.409 | 1.400 | 1.417 | 1.400 | 1.417 | 1.400 | 1.417 | 1.400 | 1.417 |
| Low | 1.398(5) | 1.407(4) | 1.397(4,5) | 1.413(4) | 1.397(4,5) | 1.413(4) | 1.397(4,5) | 1.413(4) | 1.397(4,5) | 1.413(4) |

***--() indicates which cell

KEY HIGH CELL
: LOW CELL
: AVERAGE

PACK NUMBER IS 228A
SHADOW PERIOD IS 02
CYCLE NUMBER IS 225
DISCHARGE RATE IS A.

WQEC/C 81-120A

AMPERE HOUR OUT

1.97 1.74 3.88 5.82 7.75 9.69 11.62 13.55 15.47
2.91 4.85 6.78 8.72 10.65 12.58 14.51

C
A
P
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78
79
80
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92
93
94
95
96
97
98
99
100

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1. 9. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 87. 95. 102. 116.

TIME IN MINUTES
CELLS INCLUDED V4 V4

FIGURE 242

ORIGINAL PAGE IS
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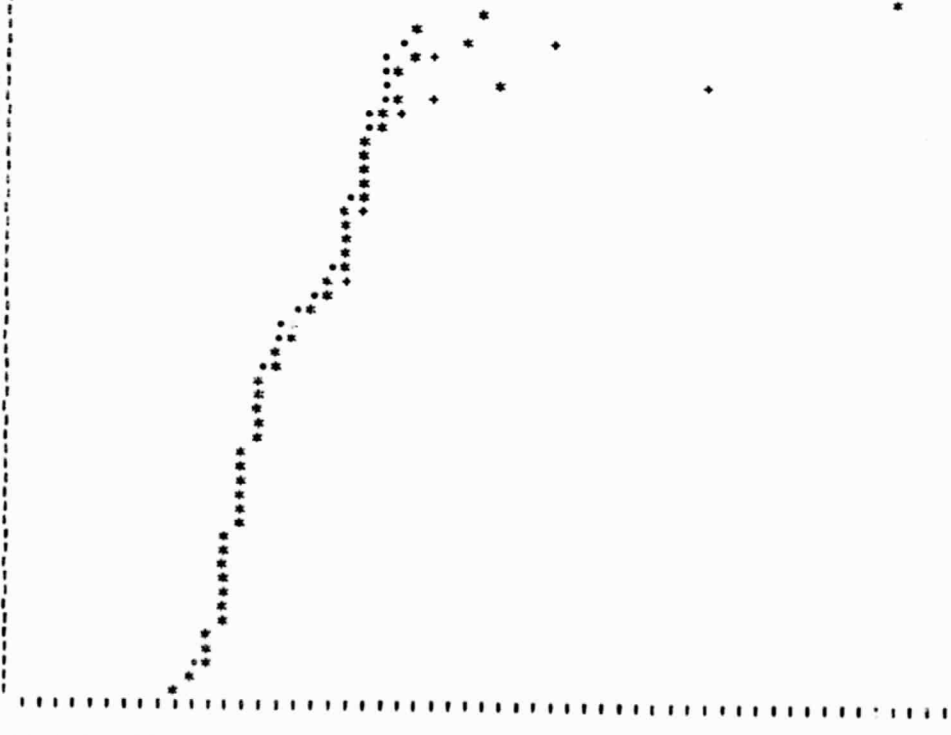
KEY
• HIGH CELL
• LOW CELL
• AVERAGE

PACK NUMBER IS 228A
SHADOW PERIOD 15 04
CYCLE NUMBER IS 0594
DISCHARGE RATE 15 8.

AMPERE HOUR OUT-

09 2.06 4.04 6.01 7.98 9.79 11.76 13.65 15.61 15.77
1.07 3.05 5.02 7.00 8.81 10.78 12.58 14.46

C A P A C I T Y C E L L V O L T A G E S C A L E



TIME IN MINUTES
CELLS INCLUDED V-3 V-4 V-5

FIGURE 244

PACK NUMBER IS 228A
 SHADOW PERIOD IS 05
 CYCLE NUMBER IS 00730
 DISCHARGE RATE IS 8.0

AMPERE HOUR OUT

1. 1.92 3.52 5.11 6.70 8.30 9.92 11.54
 1.11 2.71 4.33 5.90 7.49 9.11 10.70

00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

C A P A C I T Y C E L L V O L T A G E S C A L E

ORIGINAL PAGE IS
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1. 8. 15. 22. 29. 38. 44. 51. 58. 65. 73. 80. 87. 94. 101.

TIME IN MINUTES
 CELLS INCLUDED V-5

FIGURE 245

ORIGINAL PAGE IS
OF POOR QUALITY

PACK NUMBER IS 228A
SHADOW PERIOD IS 6
CYCLE NUMBER IS 913
DISCHARGE RATE IS 8.0

AMPERE HOUR OUT

KEY
HIGH CELL
LOW CELL
AVERAGE

32 2.28 4.25 6.21 8.16 10.11 12.06 13.28
1.30 3.27 5.23 7.18 9.13 11.08 12.95

60
57
54
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
-42
-45
-48
-51
-54
-57
-60

C A P A C I T Y C E L L V O L T A G E S C A L E

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 89. 107.
TIME IN MINUTES
CELLS INCLUDED V-4 V-5

ORIGINAL PAGE IS
OF POOR QUALITY

BACK NUMBER IS 528A
STADCOM PERIOD IS 07-1093
CYCLE NUMBER IS 8
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

KEY HIGH CELL
• LOW CELL
• AVERAGE

1. 8. 15. 22. 29. 37. 44. 51. 58. 65. 73. 80. 87. 94. 97.

C A P A C I T Y C E L L V O L T A G E S C A L E

TIME IN MINUTES
CELLS INCLUDED V-5

FIGURE 247

PACK NUMBER IS 628A
SHADOW PERIOD IS 09
CYCLE NUMBER IS 1456
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

32. 2.24 4.17 6.10 8.02 9.93 11.83 13.41
1.28 3.21 5.13 7.06 8.98 10.88 12.78

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E

97
95
93
91
89
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0

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OF POOR QUALITY

TIME IN MINUTES
CELLS INCLUDED V-5

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 100.

FIGURE 249

PACK NUMBER IS 228A
 SHADOW REFLECTOR IS 15
 CYCLE NUMBER IS 104
 DISCHARGE RATE IS 0.

AMPERE HOUR OUT

1.13 2.15 3.00 4.03 5.97 7.90 9.84 11.76 13.69 14.32
 15.01 16.81 18.61 20.41 22.21 24.01 25.81 27.61 29.41 31.21
 33.01 34.81 36.61 38.41 40.21 42.01 43.81 45.61 47.41 49.21
 51.01 52.81 54.61 56.41 58.21 60.01 61.81 63.61 65.41 67.21
 69.01 70.81 72.61 74.41 76.21 78.01 79.81 81.61 83.41 85.21
 87.01 88.81 90.61 92.41 94.21 96.01 97.81 99.61 101.41 103.21
 105.01 106.81 108.61 110.41 112.21 114.01 115.81 117.61 119.41 121.21
 123.01 124.81 126.61 128.41 130.21 132.01 133.81 135.61 137.41 139.21
 141.01 142.81 144.61 146.41 148.21 150.01 151.81 153.61 155.41 157.21
 159.01 160.81 162.61 164.41 166.21 168.01 169.81 171.61 173.41 175.21
 177.01 178.81 180.61 182.41 184.21 186.01 187.81 189.61 191.41 193.21
 195.01 196.81 198.61 200.41 202.21 204.01 205.81 207.61 209.41 211.21
 213.01 214.81 216.61 218.41 220.21 222.01 223.81 225.61 227.41 229.21
 231.01 232.81 234.61 236.41 238.21 240.01 241.81 243.61 245.41 247.21
 249.01 250.81 252.61 254.41 256.21 258.01 259.81 261.61 263.41 265.21
 267.01 268.81 270.61 272.41 274.21 276.01 277.81 279.61 281.41 283.21
 285.01 286.81 288.61 290.41 292.21 294.01 295.81 297.61 299.41 301.21
 303.01 304.81 306.61 308.41 310.21 312.01 313.81 315.61 317.41 319.21
 321.01 322.81 324.61 326.41 328.21 330.01 331.81 333.61 335.41 337.21
 339.01 340.81 342.61 344.41 346.21 348.01 349.81 351.61 353.41 355.21
 357.01 358.81 360.61 362.41 364.21 366.01 367.81 369.61 371.41 373.21
 375.01 376.81 378.61 380.41 382.21 384.01 385.81 387.61 389.41 391.21
 393.01 394.81 396.61 398.41 400.21 402.01 403.81 405.61 407.41 409.21
 411.01 412.81 414.61 416.41 418.21 420.01 421.81 423.61 425.41 427.21
 429.01 430.81 432.61 434.41 436.21 438.01 439.81 441.61 443.41 445.21
 447.01 448.81 450.61 452.41 454.21 456.01 457.81 459.61 461.41 463.21
 465.01 466.81 468.61 470.41 472.21 474.01 475.81 477.61 479.41 481.21
 483.01 484.81 486.61 488.41 490.21 492.01 493.81 495.61 497.41 499.21
 501.01 502.81 504.61 506.41 508.21 510.01 511.81 513.61 515.41 517.21
 519.01 520.81 522.61 524.41 526.21 528.01 529.81 531.61 533.41 535.21
 537.01 538.81 540.61 542.41 544.21 546.01 547.81 549.61 551.41 553.21
 555.01 556.81 558.61 560.41 562.21 564.01 565.81 567.61 569.41 571.21
 573.01 574.81 576.61 578.41 580.21 582.01 583.81 585.61 587.41 589.21
 591.01 592.81 594.61 596.41 598.21 600.01 601.81 603.61 605.41 607.21
 609.01 610.81 612.61 614.41 616.21 618.01 619.81 621.61 623.41 625.21
 627.01 628.81 630.61 632.41 634.21 636.01 637.81 639.61 641.41 643.21
 645.01 646.81 648.61 650.41 652.21 654.01 655.81 657.61 659.41 661.21
 663.01 664.81 666.61 668.41 670.21 672.01 673.81 675.61 677.41 679.21
 681.01 682.81 684.61 686.41 688.21 690.01 691.81 693.61 695.41 697.21
 699.01 700.81 702.61 704.41 706.21 708.01 709.81 711.61 713.41 715.21
 717.01 718.81 720.61 722.41 724.21 726.01 727.81 729.61 731.41 733.21
 735.01 736.81 738.61 740.41 742.21 744.01 745.81 747.61 749.41 751.21
 753.01 754.81 756.61 758.41 760.21 762.01 763.81 765.61 767.41 769.21
 771.01 772.81 774.61 776.41 778.21 780.01 781.81 783.61 785.41 787.21
 789.01 790.81 792.61 794.41 796.21 798.01 799.81 801.61 803.41 805.21
 807.01 808.81 810.61 812.41 814.21 816.01 817.81 819.61 821.41 823.21
 825.01 826.81 828.61 830.41 832.21 834.01 835.81 837.61 839.41 841.21
 843.01 844.81 846.61 848.41 850.21 852.01 853.81 855.61 857.41 859.21
 861.01 862.81 864.61 866.41 868.21 870.01 871.81 873.61 875.41 877.21
 879.01 880.81 882.61 884.41 886.21 888.01 889.81 891.61 893.41 895.21
 897.01 898.81 900.61 902.41 904.21 906.01 907.81 909.61 911.41 913.21
 915.01 916.81 918.61 920.41 922.21 924.01 925.81 927.61 929.41 931.21
 933.01 934.81 936.61 938.41 940.21 942.01 943.81 945.61 947.41 949.21
 951.01 952.81 954.61 956.41 958.21 960.01 961.81 963.61 965.41 967.21
 969.01 970.81 972.61 974.41 976.21 978.01 979.81 981.61 983.41 985.21
 987.01 988.81 990.61 992.41 994.21 996.01 997.81 999.61 1001.41 1003.21
 1005.01 1006.81 1008.61 1010.41 1012.21 1014.01 1015.81 1017.61 1019.41 1021.21
 1023.01 1024.81 1026.61 1028.41 1030.21 1032.01 1033.81 1035.61 1037.41 1039.21
 1041.01 1042.81 1044.61 1046.41 1048.21 1050.01 1051.81 1053.61 1055.41 1057.21
 1059.01 1060.81 1062.61 1064.41 1066.21 1068.01 1069.81 1071.61 1073.41 1075.21
 1077.01 1078.81 1080.61 1082.41 1084.21 1086.01 1087.81 1089.61 1091.41 1093.21
 1095.01 1096.81 1098.61 1100.41 1102.21 1104.01 1105.81 1107.61 1109.41 1111.21
 1113.01 1114.81 1116.61 1118.41 1120.21 1122.01 1123.81 1125.61 1127.41 1129.21
 1131.01 1132.81 1134.61 1136.41 1138.21 1140.01 1141.81 1143.61 1145.41 1147.21
 1149.01 1150.81 1152.61 1154.41 1156.21 1158.01 1159.81 1161.61 1163.41 1165.21
 1167.01 1168.81 1170.61 1172.41 1174.21 1176.01 1177.81 1179.61 1181.41 1183.21
 1185.01 1186.81 1188.61 1190.41 1192.21 1194.01 1195.81 1197.61 1199.41 1201.21
 1203.01 1204.81 1206.61 1208.41 1210.21 1212.01 1213.81 1215.61 1217.41 1219.21
 1221.01 1222.81 1224.61 1226.41 1228.21 1230.01 1231.81 1233.61 1235.41 1237.21
 1239.01 1240.81 1242.61 1244.41 1246.21 1248.01 1249.81 1251.61 1253.41 1255.21
 1257.01 1258.81 1260.61 1262.41 1264.21 1266.01 1267.81 1269.61 1271.41 1273.21
 1275.01 1276.81 1278.61 1280.41 1282.21 1284.01 1285.81 1287.61 1289.41 1291.21
 1293.01 1294.81 1296.61 1298.41 1300.21 1302.01 1303.81 1305.61 1307.41 1309.21
 1311.01 1312.81 1314.61 1316.41 1318.21 1320.01 1321.81 1323.61 1325.41 1327.21
 1329.01 1330.81 1332.61 1334.41 1336.21 1338.01 1339.81 1341.61 1343.41 1345.21
 1347.01 1348.81 1350.61 1352.41 1354.21 1356.01 1357.81 1359.61 1361.41 1363.21
 1365.01 1366.81 1368.61 1370.41 1372.21 1374.01 1375.81 1377.61 1379.41 1381.21
 1383.01 1384.81 1386.61 1388.41 1390.21 1392.01 1393.81 1395.61 1397.41 1399.21
 1401.01 1402.81 1404.61 1406.41 1408.21 1410.01 1411.81 1413.61 1415.41 1417.21
 1419.01 1420.81 1422.61 1424.41 1426.21 1428.01 1429.81 1431.61 1433.41 1435.21
 1437.01 1438.81 1440.61 1442.41 1444.21 1446.01 1447.81 1449.61 1451.41 1453.21
 1455.01 1456.81 1458.61 1460.41 1462.21 1464.01 1465.81 1467.61 1469.41 1471.21
 1473.01 1474.81 1476.61 1478.41 1480.21 1482.01 1483.81 1485.61 1487.41 1489.21
 1491.01 1492.81 1494.61 1496.41 1498.21 1500.01 1501.81 1503.61 1505.41 1507.21
 1509.01 1510.81 1512.61 1514.41 1516.21 1518.01 1519.81 1521.61 1523.41 1525.21
 1527.01 1528.81 1530.61 1532.41 1534.21 1536.01 1537.81 1539.61 1541.41 1543.21
 1545.01 1546.81 1548.61 1550.41 1552.21 1554.01 1555.81 1557.61 1559.41 1561.21
 1563.01 1564.81 1566.61 1568.41 1570.21 1572.01 1573.81 1575.61 1577.41 1579.21
 1581.01 1582.81 1584.61 1586.41 1588.21 1590.01 1591.81 1593.61 1595.41 1597.21
 1599.01 1600.81 1602.61 1604.41 1606.21 1608.01 1609.81 1611.61 1613.41 1615.21
 1617.01 1618.81 1620.61 1622.41 1624.21 1626.01 1627.81 1629.61 1631.41 1633.21
 1635.01 1636.81 1638.61 1640.41 1642.21 1644.01 1645.81 1647.61 1649.41 1651.21
 1653.01 1654.81 1656.61 1658.41 1660.21 1662.01 1663.81 1665.61 1667.41 1669.21
 1671.01 1672.81 1674.61 1676.41 1678.21 1680.01 1681.81 1683.61 1685.41 1687.21
 1689.01 1690.81 1692.61 1694.41 1696.21 1698.01 1699.81 1701.61 1703.41 1705.21
 1707.01 1708.81 1710.61 1712.41 1714.21 1716.01 1717.81 1719.61 1721.41 1723.21
 1725.01 1726.81 1728.61 1730.41 1732.21 1734.01 1735.81 1737.61 1739.41 1741.21
 1743.01 1744.81 1746.61 1748.41 1750.21 1752.01 1753.81 1755.61 1757.41 1759.21
 1761.01 1762.81 1764.61 1766.41 1768.21 1770.01 1771.81 1773.61 1775.41 1777.21
 1779.01 1780.81 1782.61 1784.41 1786.21 1788.01 1789.81 1791.61 1793.41 1795.21
 1797.01 1798.81 1800.61 1802.41 1804.21 1806.01 1807.81 1809.61 1811.41 1813.21
 1815.01 1816.81 1818.61 1820.41 1822.21 1824.01 1825.81 1827.61 1829.41 1831.21
 1833.01 1834.81 1836.61 1838.41 1840.21 1842.01 1843.81 1845.61 1847.41 1849.21
 1851.01 1852.81 1854.61 1856.41 1858.21 1860.01 1861.81 1863.61 1865.41 1867.21
 1869.01 1870.81 1872.61 1874.41 1876.21 1878.01 1879.81 1881.61 1883.41 1885.21
 1887.01 1888.81 1890.61 1892.41 1894.21 1896.01 1897.81 1899.61 1901.41 1903.21
 1905.01 1906.81 1908.61 1910.41 1912.21 1914.01 1915.81 1917.61 1919.41 1921.21
 1923.01 1924.81 1926.61 1928.41 1930.21 1932.01 1933.81 1935.61 1937.41 1939.21
 1941.01 1942.81 1944.61 1946.41 1948.21 1950.01 1951.81 1953.61 1955.41 1957.21
 1959.01 1960.81 1962.61 1964.41 1966.21 1968.01 1969.81 1971.61 1973.41 1975.21
 1977.01 1978.81 1980.61 1982.41 1984.21 1986.01 1987.81 1989.61 1991.41 1993.21
 1995.01 1996.81 1998.61 2000.41 2002.21 2004.01 2005.81 2007.61 2009.41 2011.21
 2013.01 2014.81 2016.61 2018.41 2020.21 2022.01 2023.81 2025.61 2027.41 2029.21
 2031.01 2032.81 2034.61 2036.41 2038.21 2040.01 2041.81 2043.61 2045.41 2047.21
 2049.01 2050.81 2052.61 2054.41 2056.21 2058.01 2059.81 2061.61 2063.41 2065.21
 2067.01 2068.81 2070.61 2072.41 2074.21 2076.01 2077.81 2079.61 2081.41 2083.21
 2085.01 2086.81 2088.61 2090.41 2092.21 2094.01 2095.81 2097.61 2099.41 2101.21
 2103.01 2104.81 2106.61 2108.41 2110.21 2112.01 2113.81 2115.61 2117.41 2119.21
 2121.01 2122.81 2124.61 2126.41 2128.21 2130.01 2131.81 2133.61 2135.41 2137.21
 2139.01 2140.81 2142.61 2144.41 2146.21 2148.01 2149.81 2151.61 2153.41 2155.21
 2157.01 2158.81 2160.61 2162.41 2164.21 2166.01 2167.81 2169.61 2171.41 2173.21
 2175.01 2176.81 2178.61 2180.41 2182.21 2184.01 2185.81 2187.61 2189.41 2191.21
 2193.01 2194.81 2196.61 2198.41 2200.21 2202.01 2203.81 2205.61 2207.41 2209.21
 2211.01 2212.81 2214.61 2216.41 2218.21 2220.01 2221.81 2223.61 2225.41 2227.21
 2229.01 2230.81 2232.61 2234.41 2236.21 2238.01 2239.81 2241.61 2243.41 2245.21
 2247.01 2248.81 2250.61 2252.41 2254.21 2256.01 2257.81 2259.61 2261.41 2263.21
 2265.01 2266.81 2268.61 2270.41 2272.21 2274.01 2275.81 2277.61 2279.41 2281.21
 2283.01 2284.81 2286.61 2288.41 2290.21 2292.01 2293.81 2295.61 2297.41 2299.21
 2301.01 2302.81 2304.61 2306.41 2308.21 2310.01 2311.81 2313.61 2315.41 2317.21
 2319.01 2320.81 2322.61 2324.41 2326.21 2328.01 2329.81 2331.61 2333.41 2335.21
 2337.01 2338.81 2340.61 2342.41 2344.21 2346.01 2347.81 2349.61 2351.41 2353.21
 2355.01 2356.81 2358.61 2360.41 2362.21 2364.01 2365.81 2367.61 2369.41 2371.21
 2373.01 2374.81 2376.61 2378.41 2380.21 2382.01 2383.81 2385.61 2387.41 2389.21
 2391.01 2392.81 2394.61 2396.41 2398.21 2400.01 2401.81 2403.61 2405.41 2407.21
 2409.01 2410.81 2412.61 2414.41 2416.21 2418.01 2419.81 2421.61 2423.41 2425.21
 2427.01 2428.81 2430.61 2432.41 2434.21 2436.01 2437.81 2439.61 2441.41 2443.21
 2445.01 2446.81 2448.61 2450.41 2452.21 2454.01 2455.81 2457.61 2459.41 2461.21
 2463.01 2464.81 2466.61 2468.41 2470.21 2472.01 2473.81 2475.61 2477.41 2479.21
 2481.01 2482.81 2484.61 2486.41 2488.21 2490.01 2491.81 2493.61 2495.41 2497.21
 2499.01 2500.81 2502.61 2504.41 2506.21 2508.01 2509.81 2511.61 2513.41 2515.21
 2517.01 2518.81 2520.61 2522.41 2524.21 2526.01 2527.81 2529.61 2531.41 2533.21
 2535.01 2536.81 2538.61 2540.41 2542.21 2544.01 2545.81 2547.61 2549.41 2551.21
 2553.01 2554.81 2556.61 2558.41 2560.21 2562.01 2563.81 2565.61 2567.41 2569.21
 2571.01 2572.81 2574.61 2576.41 2578.21 2580.01 2581.81 2583.61 2585.41 2587.21
 2589.01 2590.81 2592.61 2594.41 2596.21 2598.01 2599.81 2601.61 2603.41 2605.21
 2607.01 2608.81 2610.61 2612.41 2614.21 2616.01 2617.81 2619.61 2621.41 2623.21
 2625.01 2626.81 2628.61 2630.41 2632.21 2634.01 2635.81 2637.61 2639.41 2641.21
 2643.01 2644.81 2646.61 2648.41 2650.21 2652.01 2653.81 2655.61 2657.41 2659.21
 2661.01 2662.81 2664.61 2666.41 2668.21 2670.01 2671.81 2673.61 2675.41 2677.21
 2679.01 2680.81 2682.61 2684.41 2686.21 2688.01 2689.81 2691.61 2693.41 2695.21
 2697.01 2698.81 2700.61 2702.41 2704.21 2706.01 2707.81 2709.61 2711.41 2713.21
 2715.01 2716.81 2718.61 2720.41 2722.21 2724.01 2725.81 2727.61 2729.41 2731.21
 2733.01 2734.81 2736.61 2738.41 2740.21

SHADE PERIOD IS 11.824
CYCLE NUMBER IS 1824
DISCHARGE RATE IS 8.

AMPERE HOUR OUT

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FROM CELL
AVERAGE

23 2.18 4.14 6.07 8.01 9.95 11.89 13.84 14.16
1.21 3.16 5.10 7.04 8.98 10.92 12.87

C 1.67
A 1.54
P 1.41
A 1.44
C 1.37
I 1.31
T 1.28
Y 1.22
C 1.19
E 1.16
L 1.13
L 1.10
V 1.07
O 1.04
L 1.01
T 0.96
A 0.93
G 0.90
E 0.87
S 0.84
C 0.81
A 0.78
L 0.75
E 0.72
S 0.69
C 0.66
A 0.63
L 0.61
E 0.58
S 0.55
C 0.52
A 0.49
L 0.46
E 0.43
S 0.40
C 0.37
A 0.34
L 0.31
E 0.28
S 0.25
C 0.22
A 0.19
L 0.16
E 0.13
S 0.10
C 0.07
A 0.04
L 0.01
E 0.00

1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 104.

TIME IN MINUTES
CELLS INCLUDED V-5

FIGURE 251

VOLTAGE DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 12
 GENERAL ELECTRIC CELLS
 PROJECT IUT
 SERIAL 091,159,088,172,094

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 228A

1.000
 1.050
 1.100
 1.150
 1.200
 1.250
 1.300
 1.350
 1.400
 1.450
 1.500

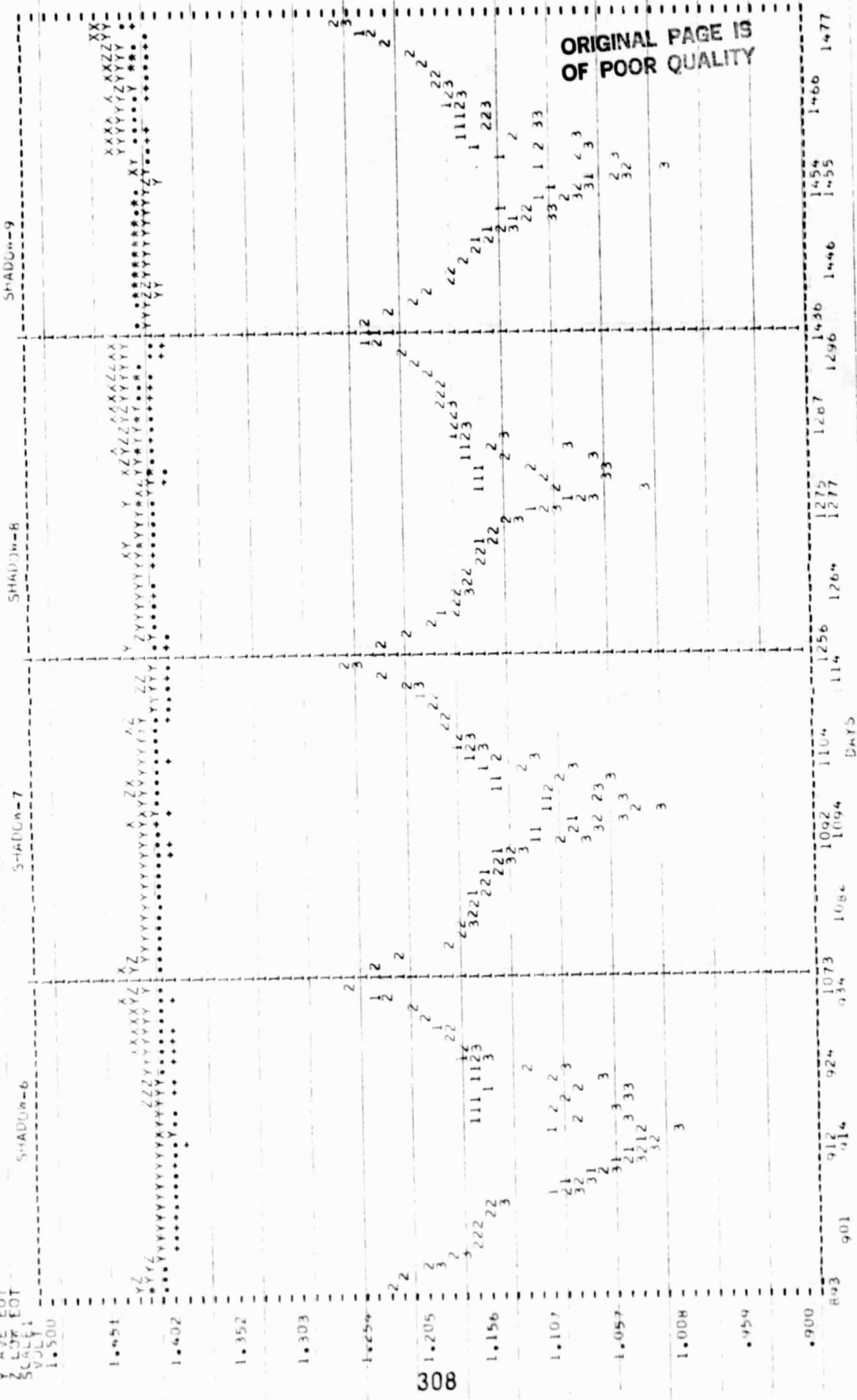


FIGURE 253

DEPTH DISCHARGE 80
TEMPERATURE 20
AMPERE RATE 12
GENERAL ELECTRIC CELLS

PROJECT IUE
SERIAL 091,159,088,172,094,

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 228A

SHADOW-

-MODVHS-

ΣΥΛΛΟΓΗ - 11

CHANDLER-10

| KEY | END | DISCHARGE | VOLTAGE |
|--------|-----|-----------|---------|
| 1 HIGH | END | DISCHARGE | VOLTAGE |
| 2 AVE | END | DISCHARGE | VOLTAGE |
| 3 LOW | END | DISCHARGE | VOLTAGE |

005
1.500
1.70A
1.37V
SCALE
LOW

1.451 -X

1.402

1.352

1.393

1.32

1.205

1.156

1.107

1.057

1.000

659

005.

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KEY
1 AHQ
2 AHQ-TOTAL
3 AHQ-TOTAL

DEPTH DISCHARGE 80
TEMPERATURE 20
AMPERE RATE 12
SERIAL 091119-088.172.094.
GENERAL ELECTRIC CELLS
PROJECT YUE

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 228A

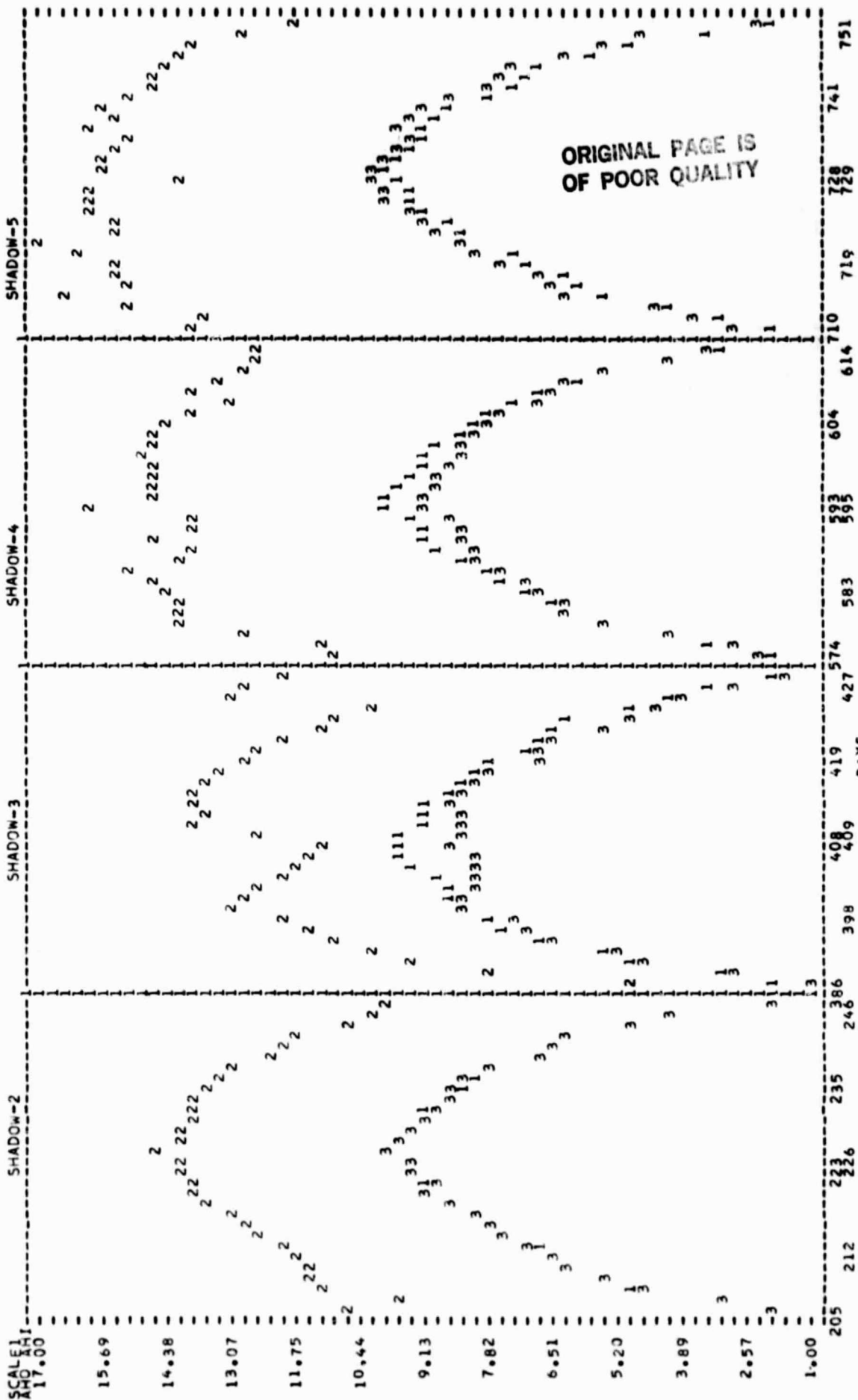


FIGURE 255

KEY
1 AMT-TOTAL
2 AMT-TOTAL
3 AMT-TOTAL

SYNCHRONOUS ORBIT SHADOW LOT

PACK = 22H.

DEPTH DISCHARGE 80
TEMPERATURE 20
RPM RATE 12
SERIAL 091,159,008,172,094.
GENERAL ELECTRIC CELLS
PROJECT 101

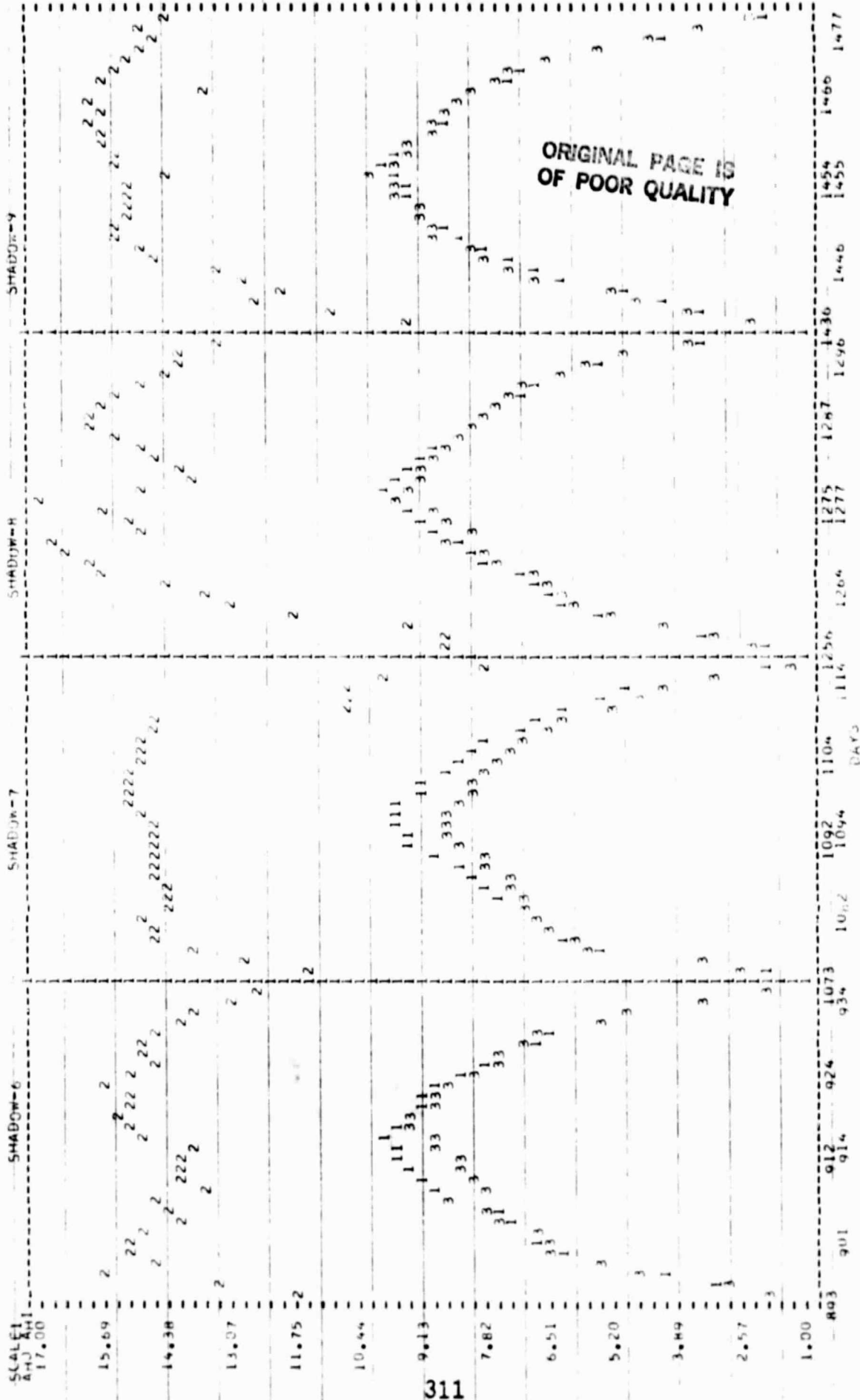


FIGURE 256

DEPTH DISCHARGE 80
TEMPERATURE 20
AMPERE RATE 12
SERIAL 091159.088.172.094.
GENERAL ELECTRIC
PROJECT IUE

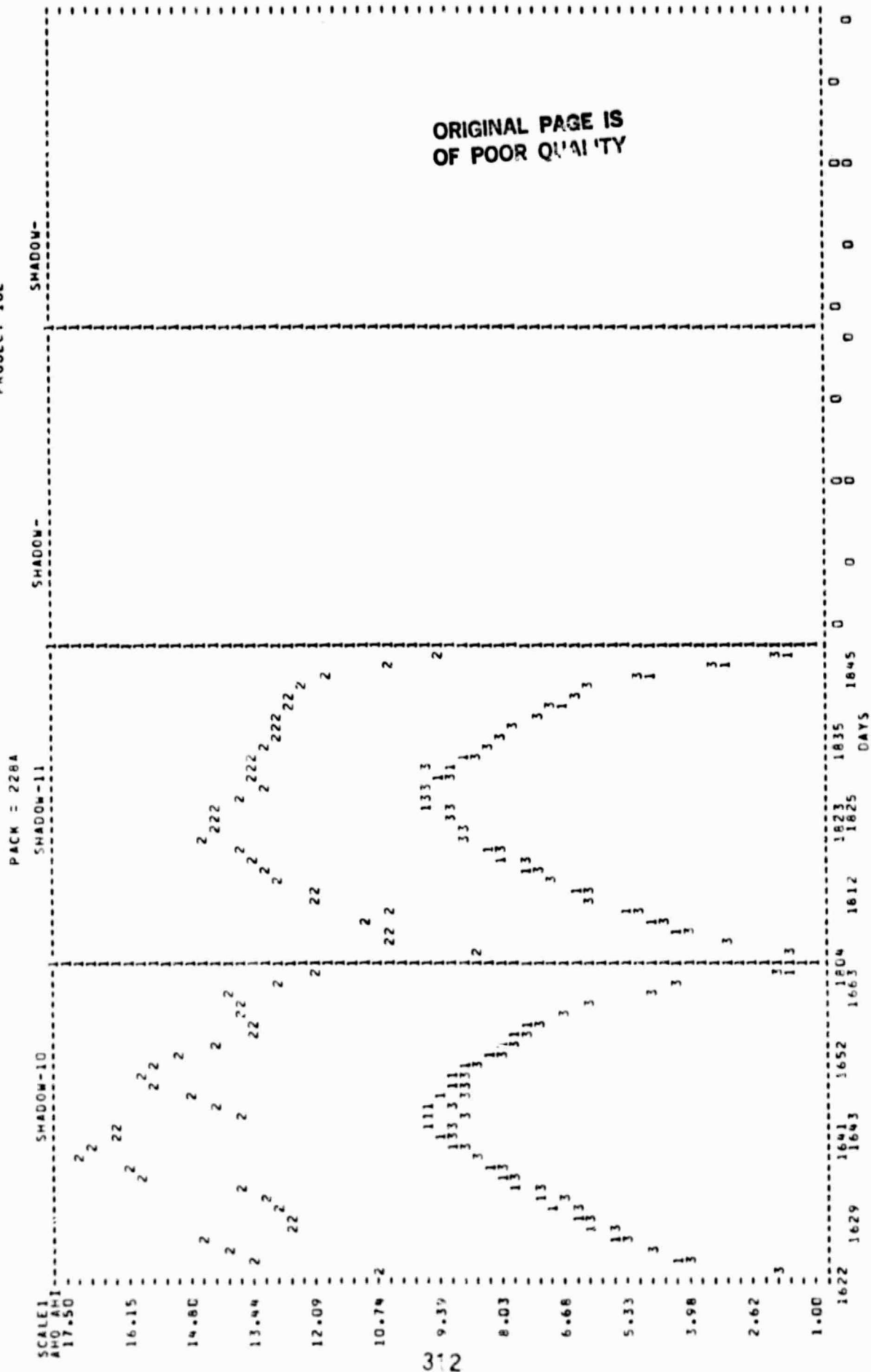


FIGURE 257

H. GU 15.0 ah (ATS 6)

1. Pack 226A, 5-cells

a. Cell information:

(1) The cells were purchased by Fairchild Industries under contract NAS-5-21100 for NASA, GSFC. The cells have the following manufacturing properties:

- (a) Number of plates: 10 negative and 9 positive
- (b) Average plate thickness: 38 mils (negative and positive plates)
- (c) Separator: non-woven nylon, Pellon 2505
- (d) Free volume: 45 cubic centimeters
- (e) Precharge: 1.0 ampere-hour
- (f) Negative/positive ratio specified: 1.40
- (g) Excess negative: 6.0 ampere-hour, minimum
- (h) Electrolyte: 43 cubic centimeters, 31%KOH

(2) Performance of these cells were presented at the 1975 GSFC Battery Workshop and the proceedings are contained in GSFC's Report X-711-76-21 of November 1975.

(3) These cells were considered as engineering cells and were activated in January 1972. They received acceptance tests at GSFC, 19.9 ah (25°C) and 15.8 ah (0°C), before being placed on a synchronous orbit test regime at GSFC.

(4) The cells completed their first 2 eclipse seasons at GSFC. The cells were fitted with pressure transducers prior to testing at NAVWPNSUPPCEN Crane. The results of eclipse seasons 3 through 8 were reported in the Crane Report WQEC/C 77-134 of 9 June 1977.

b. Parameters:

| | | | |
|--------------------------|------|----------------------|-------|
| Depth of Discharge (%) | 50 | Voltage Limit (v/c) | 1.410 |
| Charge Control | VL | Temperature (°C) | 20 |
| Charge Current (amps) | 1.50 | Float Voltage (v/c)* | 1.410 |
| Discharge Current (amps) | 6.25 | | |

*--Following shadow period 5, pack was placed on float with a voltage limit, was previously constant current (.25 amperes) returned to constant current during sun period 11.

LOAD MODE TEST--One discharge (50% DOD at the 1.87 ampere rate) per day. Recharge at 1.5 ampere to an average voltage per cell of 1.410 volts.

c. Capacity checks:

(1) Precycling and Shadow: (Discharge to .50 volts any cell or to an average of 1.00 volts per cell, whichever occurs first).

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell
5 | ah
out |
|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Precycling ** | 18.72 | 19.22 | 18.72 | 18.20 | 18.72 | |
| Shadow 3 | 1.030 | 1.055 | .667 | 1.010 | 1.070 | 20.42 |
| Shadow 4 | .998 | 1.001 | .982 | 1.002 | 1.013 | 18.10 |
| Shadow 5 | .991 | .990 | .988 | 1.004 | 1.008 | 18.79 |
| Shadow 6 | .996 | .994 | .992 | 1.007 | 1.009 | 18.50 |
| Shadow 7 | .990 | .993 | .999 | .998 | 1.001 | 18.83 |
| Shadow 8 | .992 | .997 | .998 | .999 | 1.002 | 17.57 |
| Shadow 9 (Figure 258) | .994 | 1.001 | 1.004 | 1.000 | 1.004 | 16.88 |
| Shadow 10 (Figure 259) | .990 | 1.000 | 1.003 | .996 | 1.001 | 16.23 |
| Shadow 11 (Figure 260) | .989 | .995 | 1.002 | .995 | 1.000 | 16.00 |
| Shadow 12 (Figure 261) | .987 | .992 | .997 | .992 | 1.000 | 15.07 |
| Shadow 13 (Figure 262) | .995 | .999 | 1.000 | .994 | 1.002 | 14.44 |
| Shadow 14 (Figure 263) | .989 | .993 | 1.004 | .992 | 1.001 | 13.93 |
| Shadow 15 (Figure 264) | .993 | .999 | 1.007 | .993 | 1.000 | 13.89 |
| Shadow 16 (Figure 265) | .989 | .997 | 1.001 | .990 | .996 | 13.65 |
| Shadow 17 (Figure 266) | 19.07 | 18.76 | 18.76 | 18.76 | 19.07 | 13.78 |
| Post Cycling (Figure 267) | 16.44 | 16.44 | 16.44 | 16.44 | 16.20 | 15.95 |

**--Precycling prior to shadow 3.

d. Test results during the Shadow Periods: (Figures 268 to 276)

(1) End of Discharge Voltages: The average voltages, the day prior to the capacity checks, decreased from 1.182 (shadow 4) to 1.116 volts (shadow 17). This was a very steady decline and the cells were balanced as the maximum variation, on those days, was 4 mv between the high and low cell voltages. Maximum variation occurred at the beginning of shadows 16 and 17 which corresponded with maximum cell unbalance at the end of sun periods 15 and 16. Effect of the reconditioning of the pack, due to the capacity checks and the daily discharges, can be seen for each shadow. The greatest effect was during shadow 4, which followed the Load Mode Test.

(2) The pack was placed on a Load Mode Test during the sun period following shadow 3. The pack completed 94 cycles (50% DOD-4 hours, 24 hour orbit) during this period. The pack was placed on float for 1 week prior to and following this test.

(3) End of Charge Voltages and Recharge: Unbalanced cell voltages began at the start of shadow 10, and then were present both at the start and end of each following shadow. During these shadows, the unbalance was maximum at the start and minimum in the middle of each shadow. The unbalance began following the first sun period (9) in which

there was more than a 10 mv variation in the cell voltages at the end of float. Maximum recharge occurred during shadow 12, following a steady increase during the 3 preceeding shadows, and then began to decline during each following shadow. The decline followed the pack being placed on a constant current float mode during the sun periods.

(4) Pressure at End of Charge: The maximum average end of charge pressure was 8 psia during shadow 3. This steadily decreased to 0 psia during shadow 8 but was 2 psia when the pack was discontinued. During float 4, three of the five pressure transducers (on cells 1, 3 and 5) were damaged by a power surge during an electrical storm.

(5) The pack was discontinued in the middle of shadow 17 in which each cell was discharged to .50 volts.

(6) Capacity Checks and Post Cycling: Loss of capacity, when discharged to 1.00 v/c average, was 32.5 percent from shadow 3 to when the pack was discontinued. However, this loss was only 8 percent when comparing capacities to .50 v/c. The average post cycling capacity was 16.40 ah following a 1.50 ampere charge for 22 hours at 20°C with a voltage limit of 1.410 v/c. This is a loss of 12.4 percent from that obtained during precycling; but only .5 ah was available below 1.00 v/c as was the case during precycling.

e. Performance during Sun Periods: The pack completed 14 sun periods at NAVWPN SUPPCEN Crane as it began test with a shadow period. Sun period numbers refer to the period following that shadow period with the same numbers. Following shadow 3 the pack was placed on float (.25 amperes) for one week prior to the start of the Load Mode Test. Following this test the pack was placed on float (.25 amperes) for one week prior to the start of shadow 4. The pack was placed on a .25 ampere constant-current charge during sun period 4. Starting with period 5, the pack was floated at its voltage limit of 1.410 volts per cell average until during the middle of period 11 when it was placed on a .25 amp charge current, because its voltage limit could not be maintained with a current of 1.50 amps. The pressures did not exceed 5 psia during any sun periods. Following is a listing of the high, average and low cell voltages and current (amps) at the start and end of each sun period.

SUN PERIODS

| | | | 3 | | 4 | | 5 | | 6 | |
|-------------|----------|----------|----------|------------|------------|----------|----------|----------|----------|----------|
| Voltages*** | | | Start | End | Start | End | Start | End | Start | End |
| High | 1.384(5) | 1.393(3) | 1.387(5) | 1.404(1,3) | 1.413(5) | 1.413(4) | 1.411(3) | 1.415(5) | 1.411(3) | 1.415(5) |
| Average | 1.383 | 1.392 | 1.386 | 1.403 | 1.410 | 1.409 | 1.410 | 1.410 | 1.410 | 1.410 |
| Low | 1.382(3) | 1.391(4) | 1.385(3) | 1.402(5) | 1.409(2,4) | 1.406(2) | 1.409(2) | 1.408(2) | 1.409(2) | 1.408(2) |
| Current | .25 | .25 | .25 | .25 | .51 | .47 | .58 | .38 | .58 | .38 |

| | | | 7 | | 8 | | 9 | | 10 | |
|----------|----------|----------|----------|------------|------------|----------|------------|----------|------------|----------|
| Voltages | | | Start | End | Start | End | Start | End | Start | End |
| High | 1.412(3) | 1.415(3) | 1.412(3) | 1.421(4,5) | 1.412(4) | 1.416(1) | 1.411(4) | 1.417(2) | 1.411(4) | 1.417(2) |
| Average | 1.411 | 1.412 | 1.410 | 1.417 | 1.410 | 1.410 | 1.409 | 1.410 | 1.409 | 1.410 |
| Low | 1.410(2) | 1.410(1) | 1.409(2) | 1.412(2) | 1.409(1,2) | 1.403(5) | 1.406(1,2) | 1.402(5) | 1.406(1,2) | 1.402(5) |
| Current | .66 | .40 | .51 | .42 | .51 | .59 | .54 | .70 | .54 | .70 |

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SUN PERIODS (CONT.)

| | 11 | | 12 | | 13 | | 14 | |
|--------------------|------------|----------|----------|----------|----------|----------|------------|----------|
| <u>Voltages***</u> | Start | End | Start | End | Start | End | Start | End |
| High | 1.413(4) | 1.390(3) | 1.388(3) | 1.396(4) | 1.392(3) | 1.387(2) | 1.392(3) | 1.400(3) |
| Average | 1.409 | 1.388 | 1.385 | 1.394 | 1.390 | 1.382 | 1.391 | 1.396 |
| Low | 1.406(1,2) | 1.386(1) | 1.382(2) | 1.391(2) | 1.388(5) | 1.377(5) | 1.390(1,2) | 1.393(5) |
| Current | .52 | .25 | .25 | .25 | .25 | .25 | .25 | .25 |

| | 15 | | 16 | |
|-----------------|----------|----------|----------|----------|
| <u>Voltages</u> | Start | End | Start | End |
| High | 1.404(4) | 1.402(2) | 1.409(4) | 1.407(2) |
| Average | 1.401 | 1.390 | 1.404 | 1.393 |
| Low | 1.398(1) | 1.382(5) | 1.400(1) | 1.383(5) |
| Current | .25 | .25 | .25 | .25 |

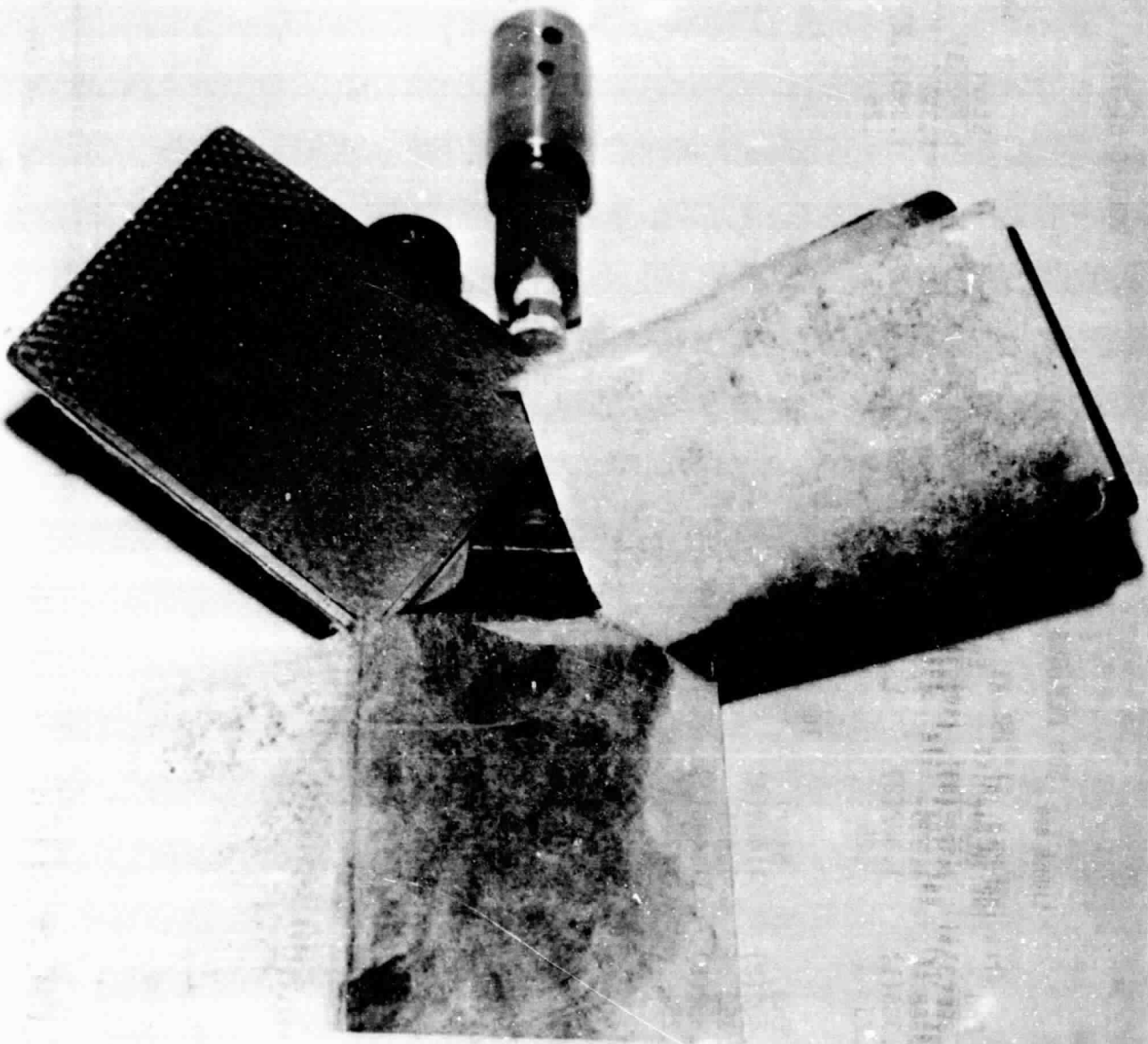
***--() indicates which cell.

f. Cell Analysis:

(1) The following photograph shows the condition of the plates and separator of cell 2 as it was opened at Crane following completion of 16.5 shadow periods.

(2) Cells 1, 3, 4 and 5 were returned to GSFC.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



Pack 226A, Cell 2, 16.5 shadow periods
at 50 percent DOD, 20°C: Slight dampness
with severe migration as evidenced by
separator adhering to negative plate.

PHOTOGRAPH 4
318

PAGE 15 226A

SHADOW
CYCLE NUMBER IS 1481
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E

.24 1.74 3.24 4.74 6.24 7.73 9.23 10.73 12.48 13.98 15.48
.99 2.49 3.99 5.49 6.99 8.48 9.98 11.48 13.23 14.73 16.23



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1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 89. 95. 102. 109. 119. 126. 133. 141. 149. 155.

CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 259

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 226A
 SHADOW NUMBER 11
 CYCLE NUMBER 15 1669
 DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

1.9 1.69 3.20 4.71 6.21 7.72 9.22 10.73 12.24 14.00 15.50 16.00
 .94 2.45 3.95 5.46 6.96 8.47 9.98 11.48 13.24 14.75

C 1.67
 A 1.54
 P 1.51
 A 1.48
 C 1.45
 I 1.42
 T 1.40
 Y 1.37
 C 1.34
 I 1.31
 T 1.28
 Y 1.25
 C 1.22
 I 1.19
 T 1.16
 Y 1.13
 C 1.10
 I 1.07
 T 1.04
 Y 1.01
 C 0.99
 I 0.96
 T 0.93
 Y 0.90
 C 0.87
 I 0.84
 T 0.81
 Y 0.78
 C 0.75
 I 0.72
 T 0.69
 Y 0.66
 C 0.63
 I 0.60
 T 0.57
 Y 0.54
 C 0.51
 I 0.48
 T 0.45
 Y 0.42
 C 0.39
 I 0.36
 T 0.33
 Y 0.30
 C 0.27
 I 0.24
 T 0.21
 Y 0.18
 C 0.15
 I 0.12
 T 0.09
 Y 0.06
 C 0.03
 I 0.00

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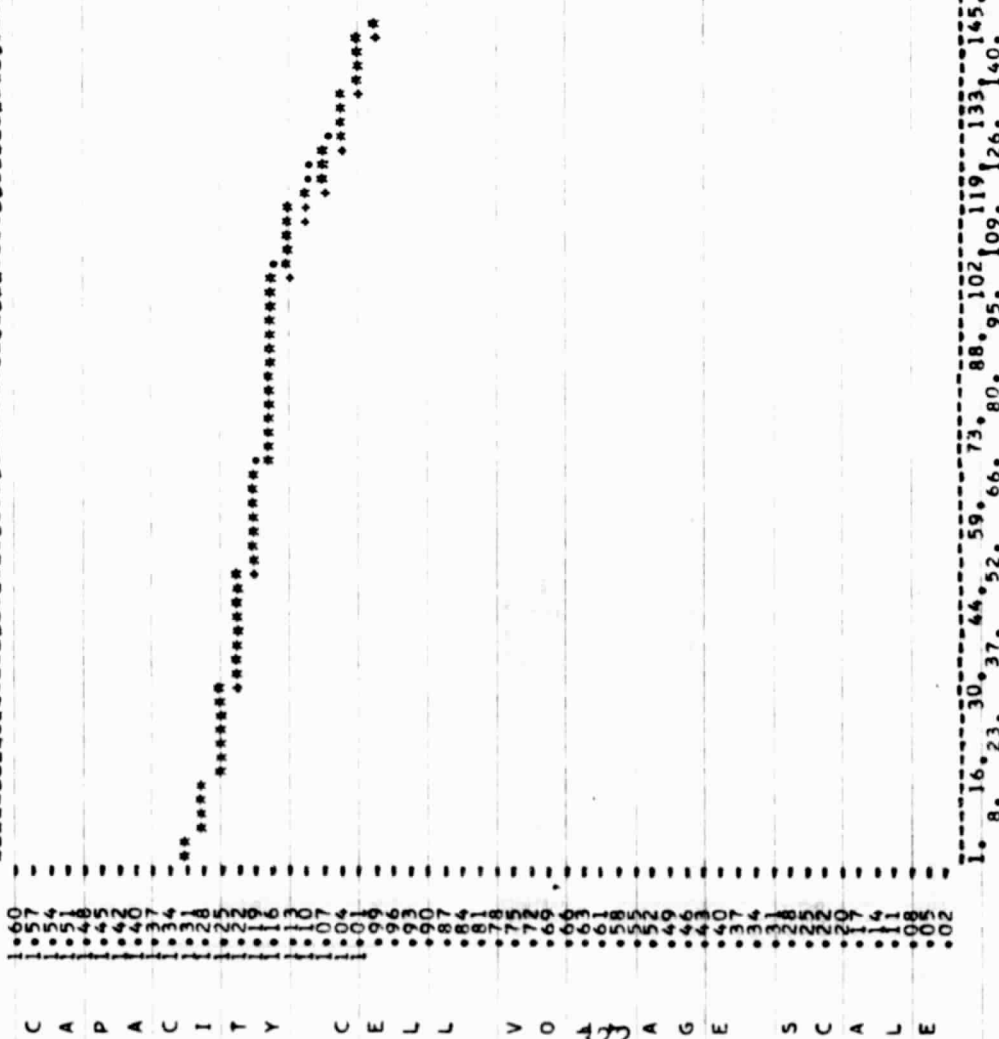
1. 9. 15. 29. 44. 59. 73. 87. 101. 116. 133. 147. 152.
 .94 2.45 3.95 5.46 6.96 8.47 9.98 11.48 13.24 14.75

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5
 FIGURE 260

KEY HIGH CELL
* LOW CELL
* AVERAGE

PACK NUMBER IS 226A
SHADOW PERIOD IS 01805
CYCLE NUMBER IS 01805
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT



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TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

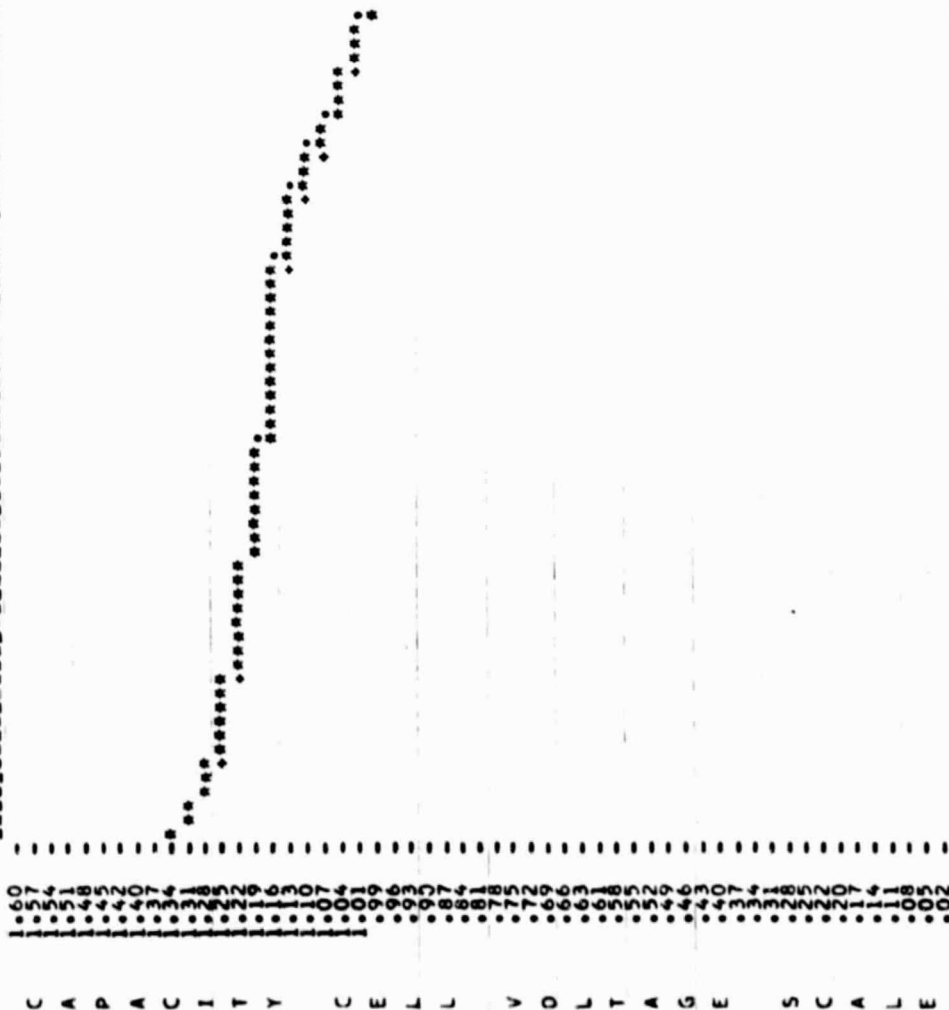
FIGURE 261

KEY
 : HIGH CELL
 : LOW CELL
 : AVERAGE

PACK NUMBER IS 226A
 SHADOW PERIOD IS 13
 CYCLE NUMBER IS 1988
 DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

.00 1.49 2.24 2.99 3.73 4.48 5.23 5.97 6.72 7.47 8.21 8.96 9.71 10.46 11.20 11.95 12.70 13.44 14.19 14.44



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1. 8. 16. 22. 29. 37. 44. 51. 58. 65. 73. 80. 87. 94. 101. 109. 116. 123. 130. 137. 140.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 262

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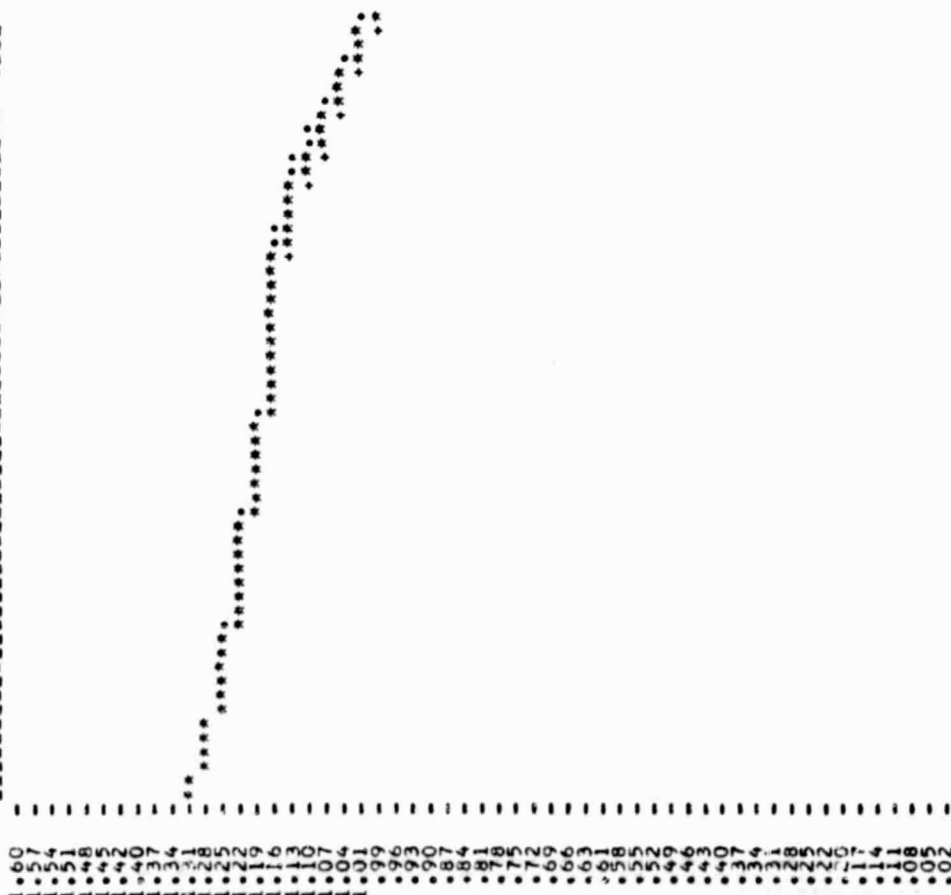
KEY
• HIGH CELL
• LOW CELL
• AVERAGE

PACK NUMBER IS 326A
SHADOW PERIOD IS 14
CYCLE NUMBER IS 2.68
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

1. 18 1.68 3.18 4.68 6.18 7.68 9.18 10.68 12.18 13.68 13.93
93 2.43 3.93 5.43 6.93 8.43 9.93 11.43 12.93

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 22. 30. 37. 44. 51. 58. 66. 73. 80. 87. 94. 102. 116. 130. 133.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

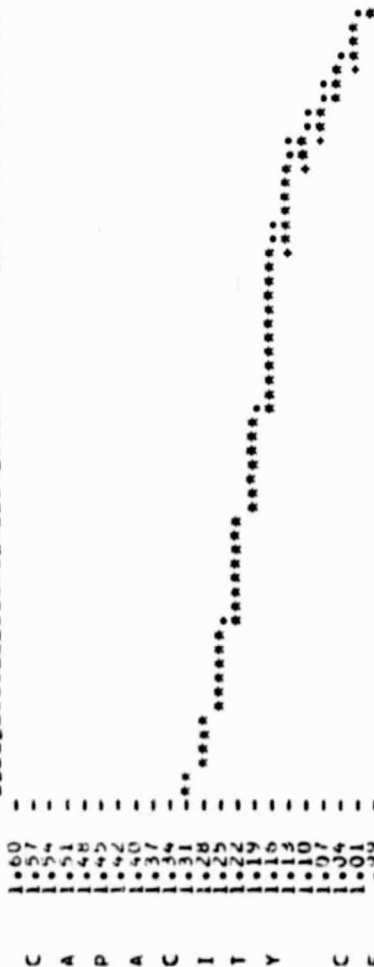
FIGURE 263

PACK NUMBER IS 226A
 SHADOW PERIOD IS 15
 CYCLE NUMBER IS 2351
 DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY HIGH CELL
 * LOW CELL
 * AVERAGE

1. 1.08 3.18 4.67 6.17 7.67 9.16 10.66 12.15 13.64 13.89
 .93 2.43 3.92 5.42 6.92 8.42 9.91 11.40 12.90



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1. 15. 30. 44. 58. 73. 87. 102. 116. 130. 133.
 8. 22. 37. 51. 67. 80. 94. 109. 123.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 264

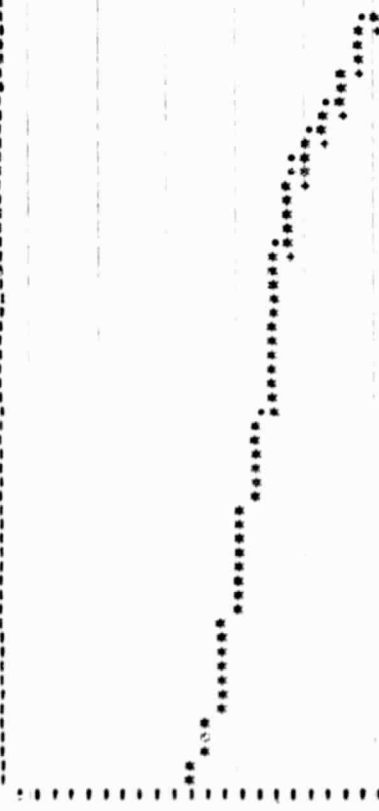
HIGH CELL
 LOW CELL
 AVERAGE

PACK NUMBER IS 226A
 SHADOW PERIOD IS 16
 CYCLE NUMBER IS 12531
 DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

0.6 1.54 3.03 4.51 6.24 7.72 9.20 10.68 12.17 13.65
 1.80 2.28 3.77 5.25 6.98 8.46 9.94 11.42 12.91

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100



ORIGINAL PAGE IS
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1. 8. 15. 22. 30. 37. 44. 51. 58. 65. 72. 79. 86. 93. 100. 107. 114. 121. 128. 135.

TIME IN MINUTES V-1 V-2 V-3 V-4 V-5
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 265

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 226A
 POST CYCLING
 CYCLE NUMBER IS 2718
 DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

12 1.63 3.11 4.59 6.07 7.55 8.04 10.57 12.00 13.48 14.96 16.44
 .87 2.37 3.85 5.33 6.81 8.30 9.78 11.26 12.74 14.22 15.70

C 1.60
 A 1.54
 P 1.51
 A 1.48
 C 1.45
 I 1.42
 Y 1.37
 Y 1.34
 C 1.31
 E 1.28
 L 1.25
 L 1.22
 V 1.19
 C 1.16
 L 1.13
 T 1.10
 A 1.07
 S 1.04
 C 1.01
 A 0.99
 L 0.96
 E 0.93
 S 0.90
 C 0.87
 A 0.84
 L 0.81
 E 0.78
 S 0.75
 C 0.72
 A 0.69
 L 0.66
 E 0.63
 S 0.60
 C 0.57
 A 0.54
 L 0.51
 E 0.48
 S 0.45
 C 0.42
 A 0.39
 L 0.36
 E 0.33
 S 0.30
 C 0.27
 A 0.24
 L 0.21
 E 0.18
 S 0.15
 C 0.12
 A 0.09
 L 0.06
 E 0.03

ORIGINAL PAGE IS
 OF POOR QUALITY

1. 8. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 87. 95. 102. 110. 116. 123. 130. 138. 145. 152. 160.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 267

DEPTH DISCHARGE 50 WQEC/C 81-120A
 TEMPERATURE 20
 AMPERE RATE 15
 GULTON CELLS

SERIAL 583 585 606 609 616

PROJECT ATS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 226A

KEY
 * HIGH END DISCHARGE VOLTAGE
 + AVE END DISCHARGE VOLTAGE
 • LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 + AVE EOC
 • LOW EOC

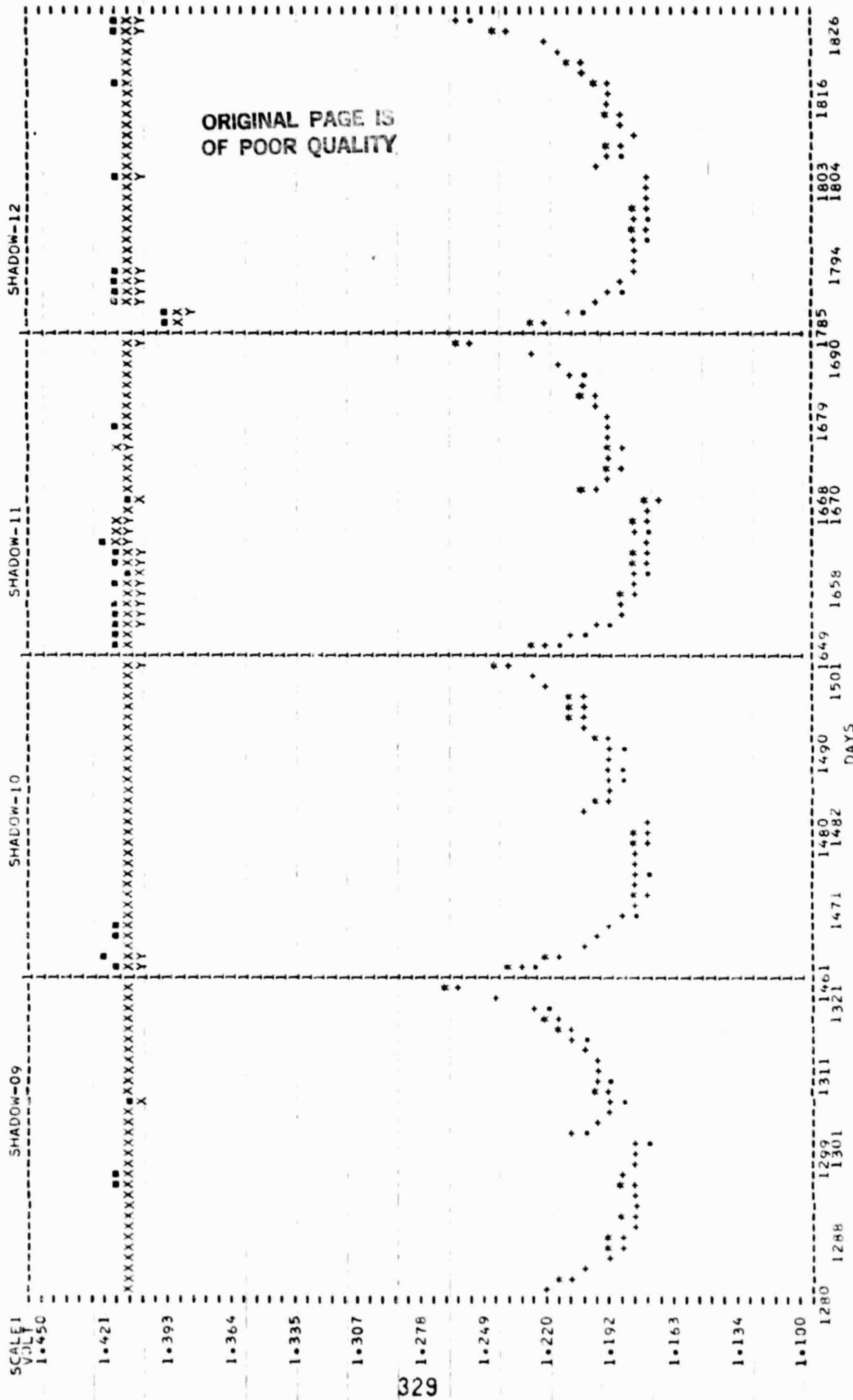


FIGURE 268

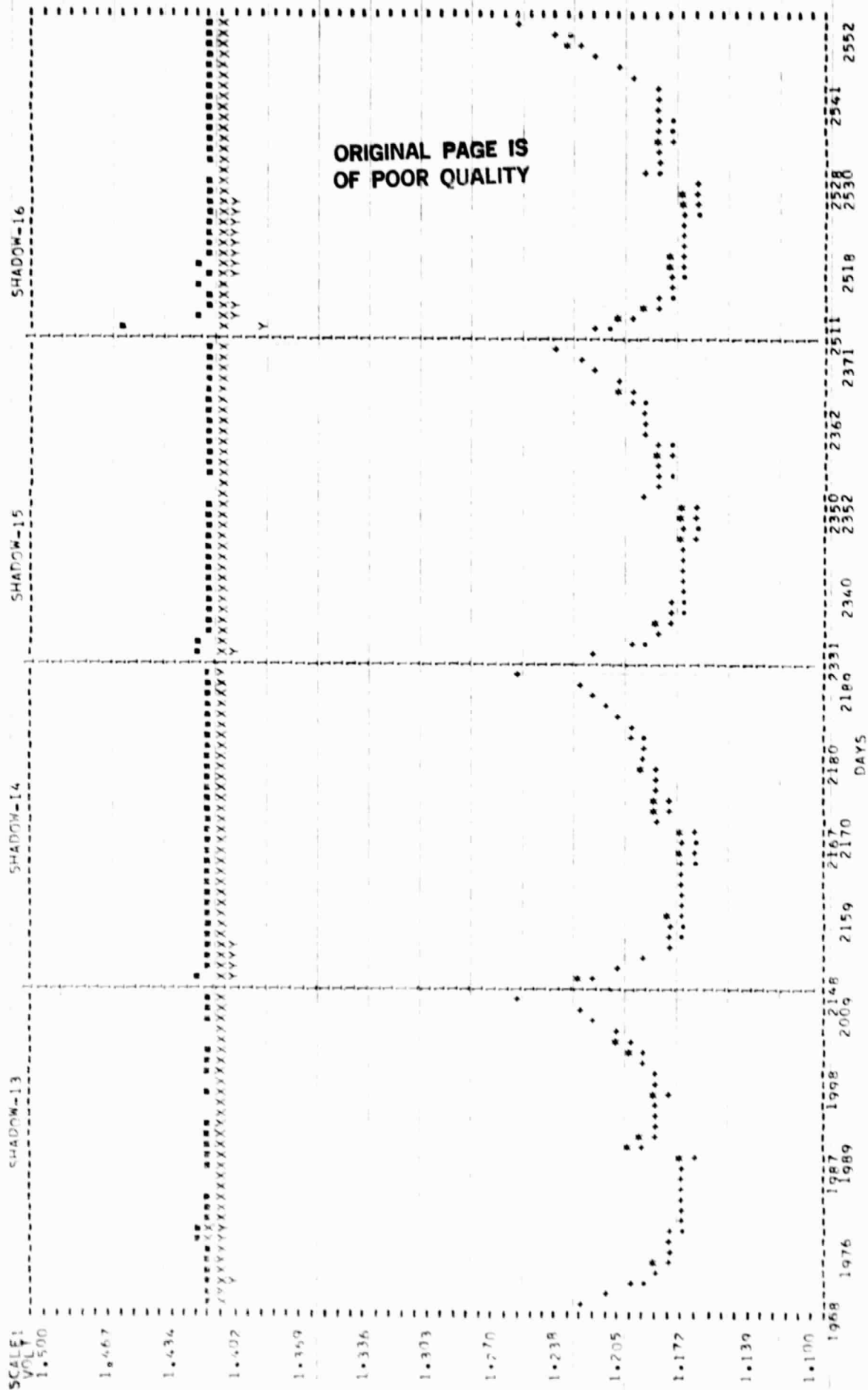
KEY
 * HIGH FID DISCHARGE VOLTAGE
 * AVE FID DISCHARGE VOLTAGE
 * LOW FID DISCHARGE VOLTAGE
 * HIGH EOC
 * AVE EOC
 * LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50 WQEC/C 81-120A
 TEMPERATURE 20
 AMPERE RATE 15
 GULTON CELLS

SERIAL 583 585 606 609 616
 PROJECT ATS

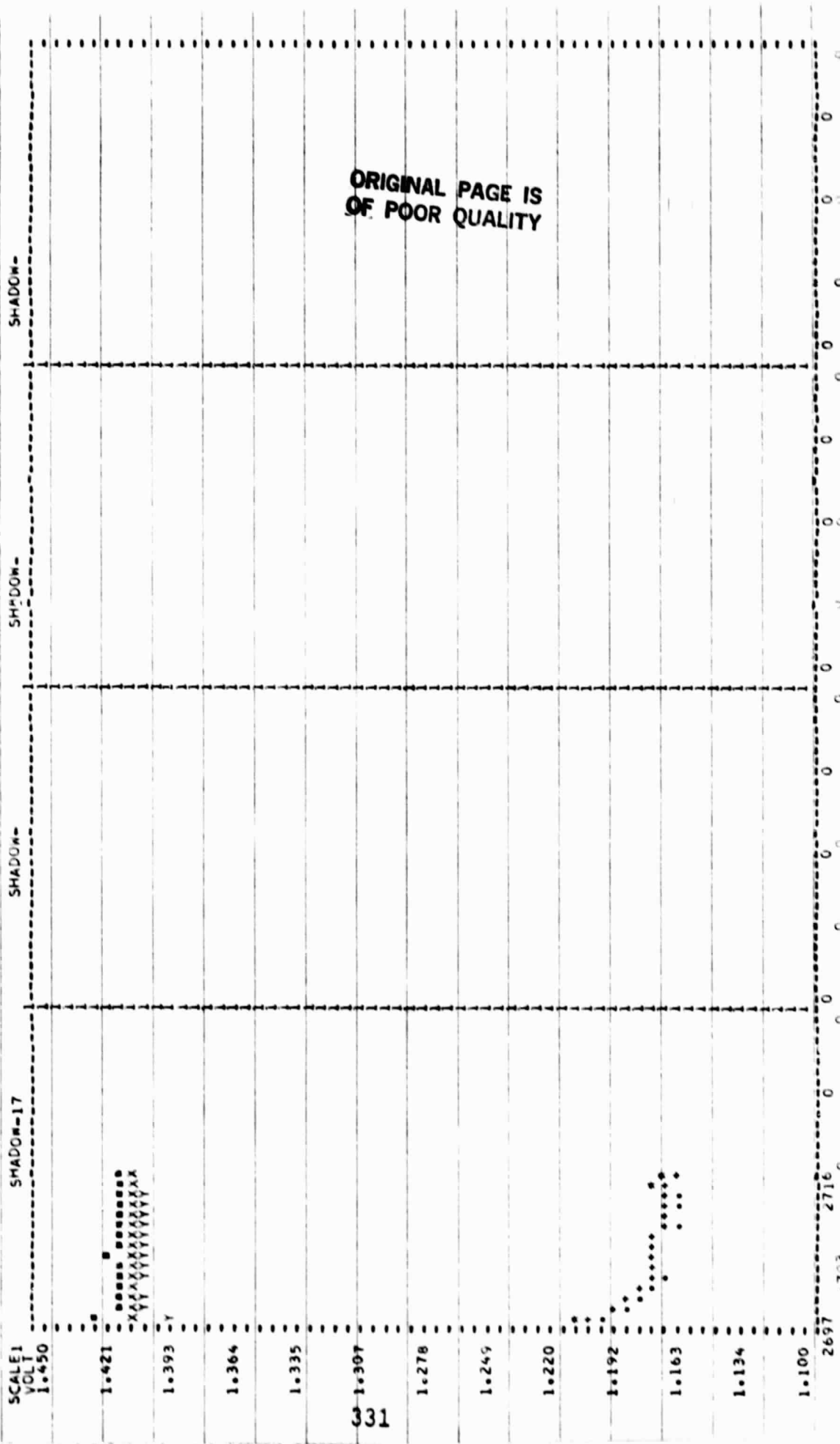
PACK = 226A



DEPTH DISCHARGE 50 WQEC/C 81-120A
TEMPERATURE 20
APPROXIMATE 15
GULFON CELLS

SERIAL 583 585 606 609 616
PROJECT ATS

PACK = 426A



* AHJ
* AHJ-TOTAL

SYNCHRONOUS GRID SHALOW PLOT

PACK = 226A

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
GULTON CELLS
SERIAL 583 585 606 609 616
PROJECT AT5

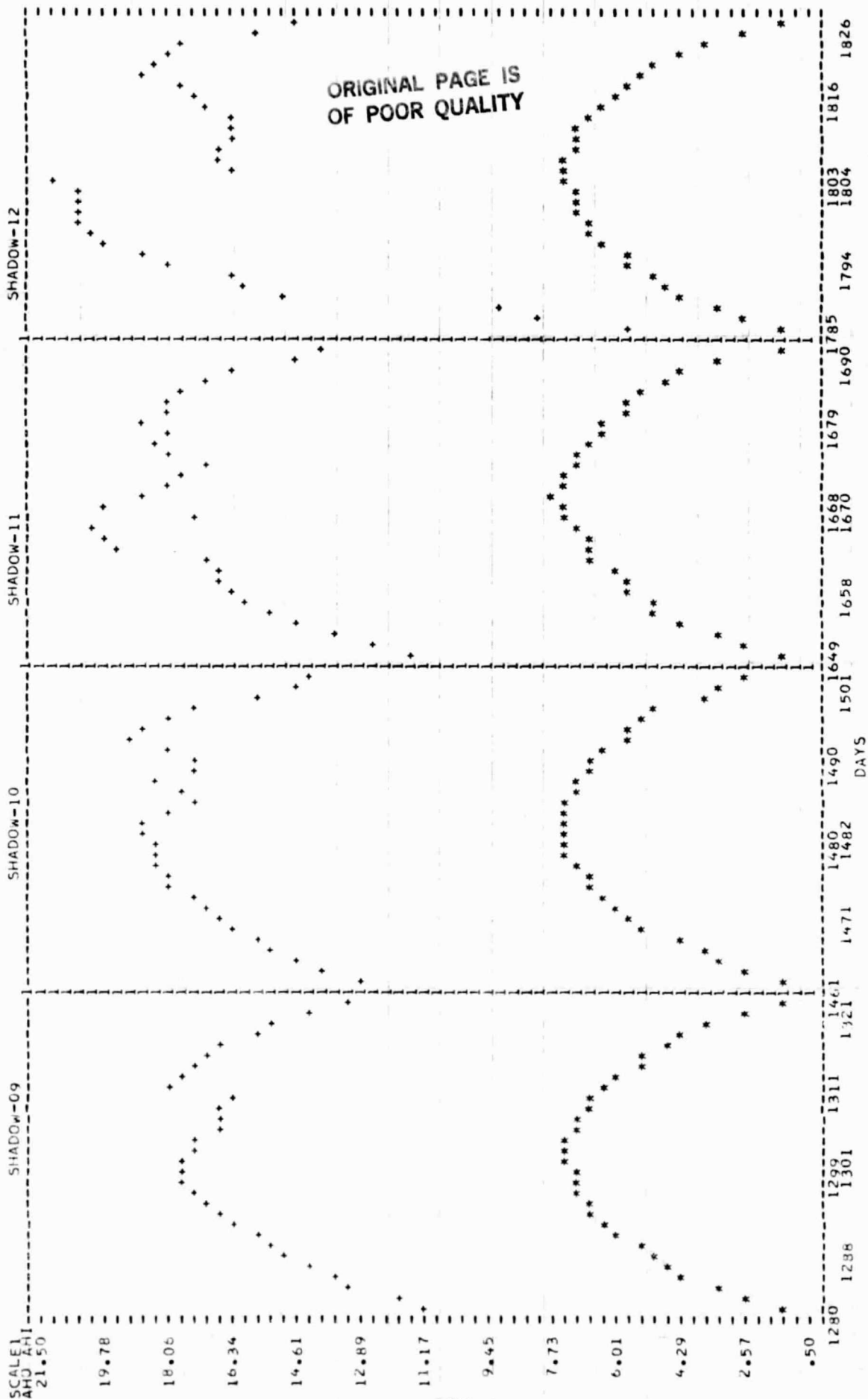


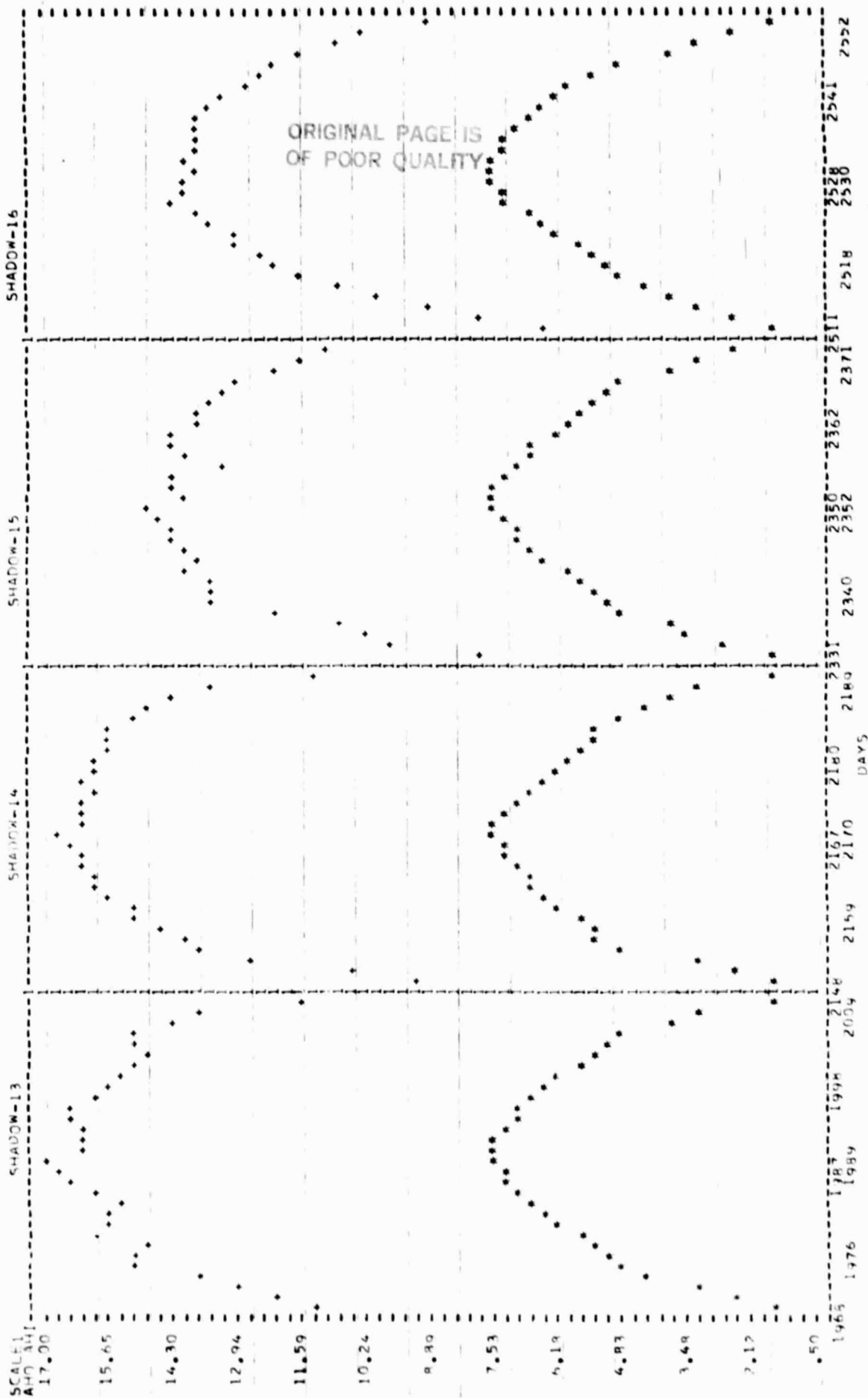
FIGURE 271

KEY
 * AHD
 * AHT-TOTAL

SYNCHRONOUS WHITE SHADOW PLD

DEPTH DISCHARGE 50 WDEC/C 81-120A
 TEMPERATURE 20
 AMPERE RATE 15
 GUNION CELLS
 SERIAL 583 585 606 609 616
 PROJECT AT5

PACK = 226A



| | | | |
|-------------|-----------|-----|----------------|
| DEPTH | DISCHARGE | 50 | WQEC/C 81-120A |
| TEMPERATURE | 20 | | |
| AMPERAGE | 15 | | |
| RATE | 15 | | |
| SOLUTION | 585 | 606 | 609 616 |
| SERIAL | 585 | | |
| PROJECT | ATS | | |

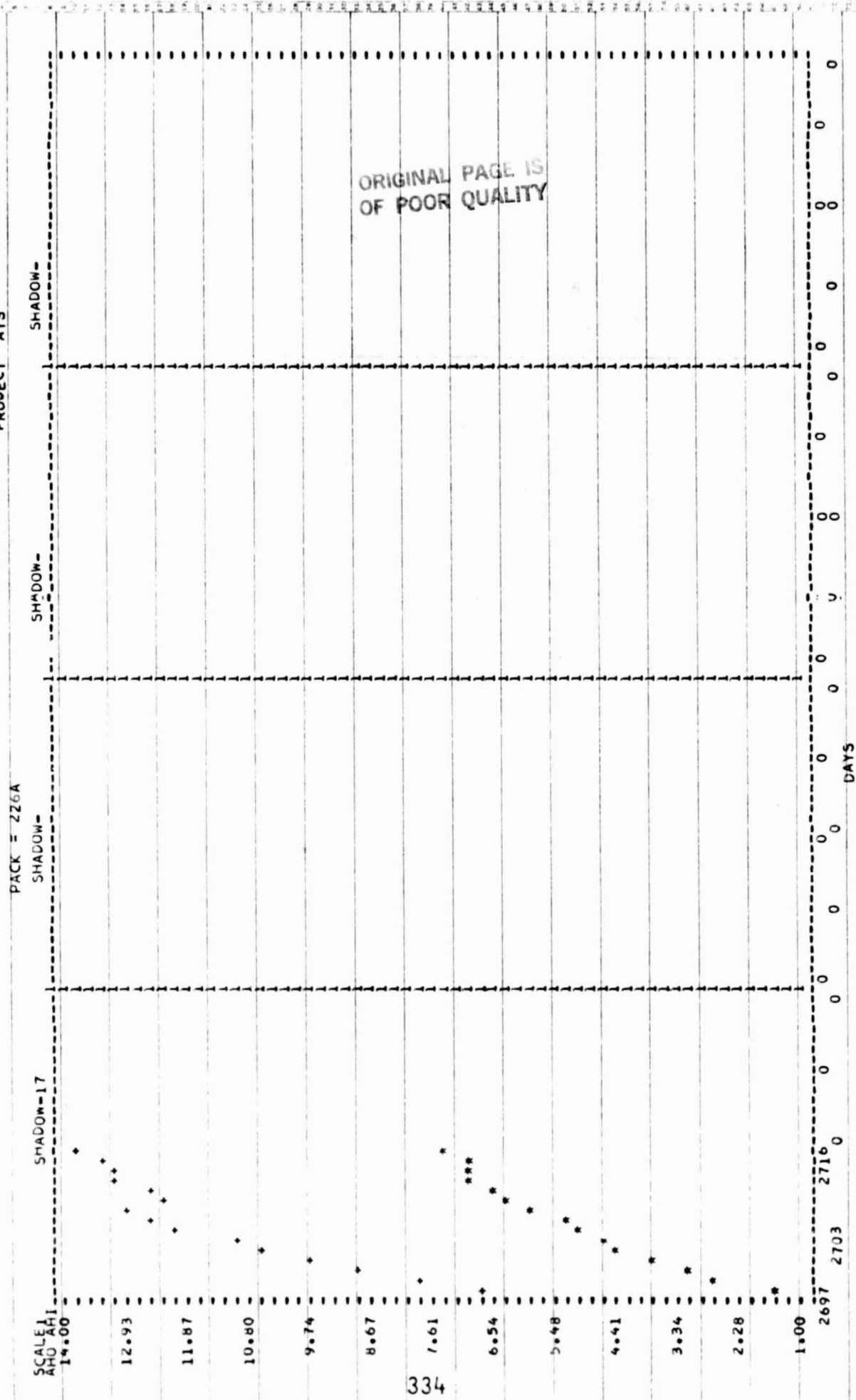


FIGURE 273

KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50 WQEC/C 81-120A
TEMPERATURE 20
AMPERE RATE 15
SERIAL 583 585 606 609 616

PROJECT AT'S
GULTON CELLS

PACK = 226A

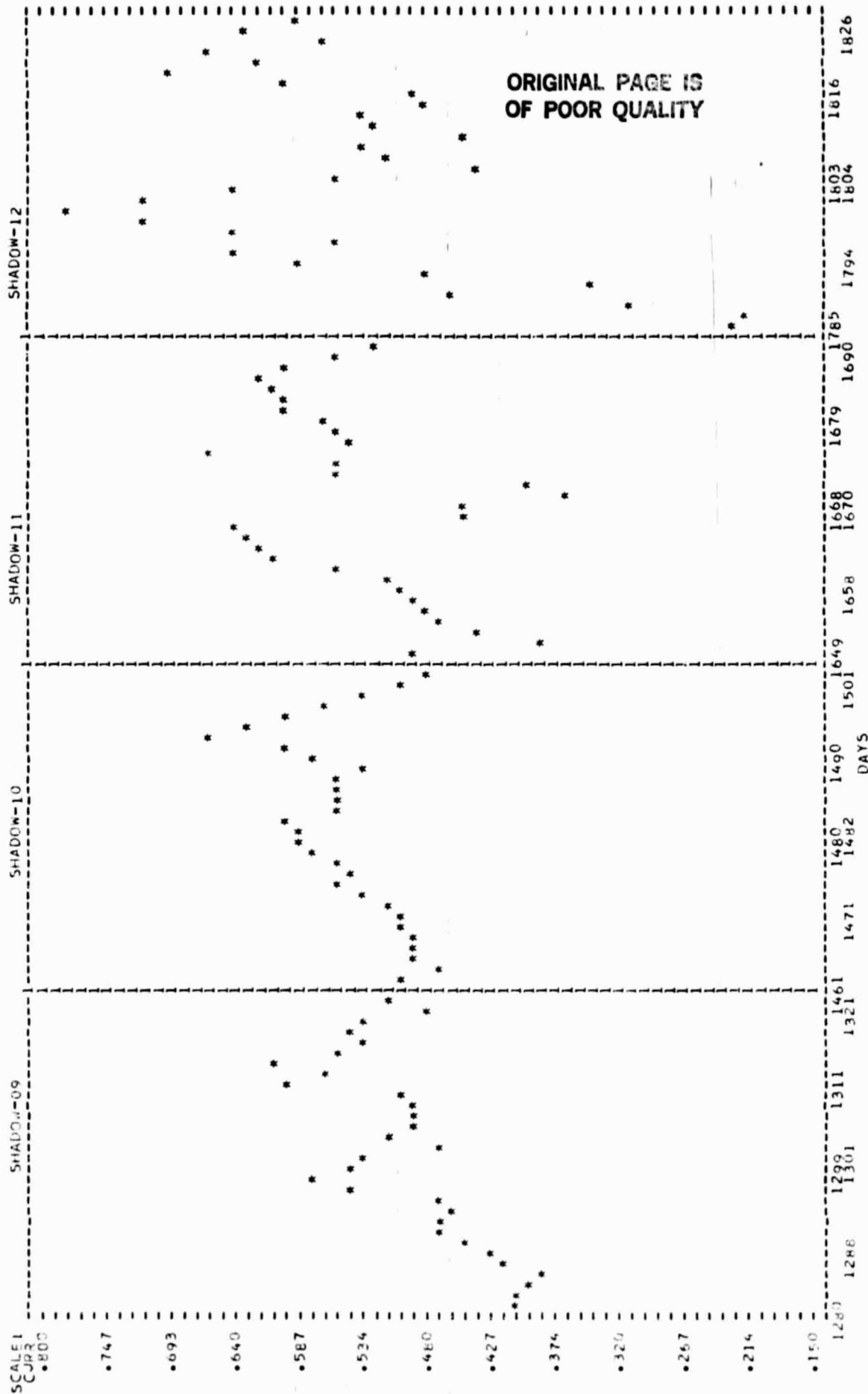


FIGURE 274

REF: C-1000r CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
SERIAL 583 585 606 609 616
PROJECT ATIS
GULTON CELLS

PACK = 226A

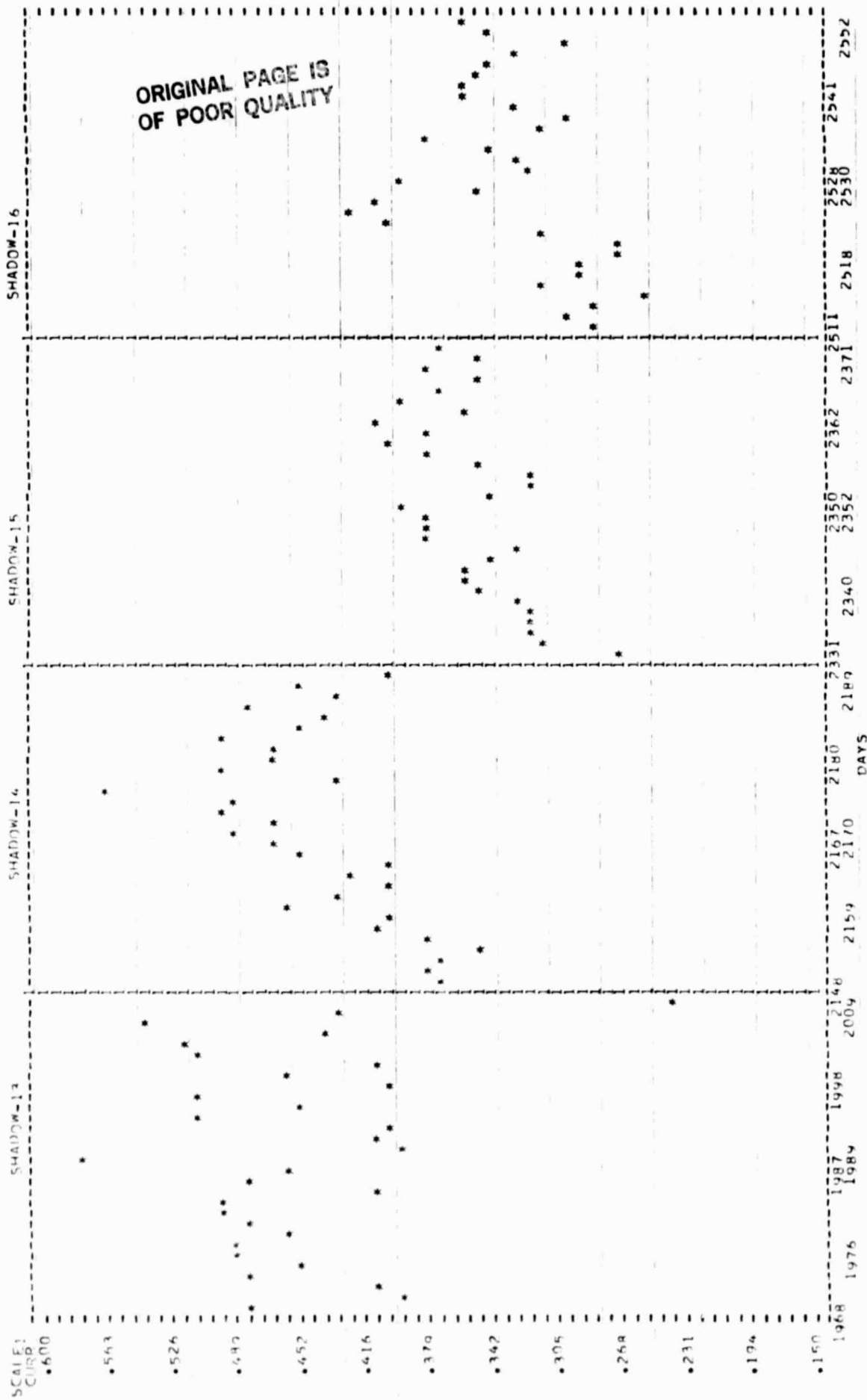


FIGURE 275

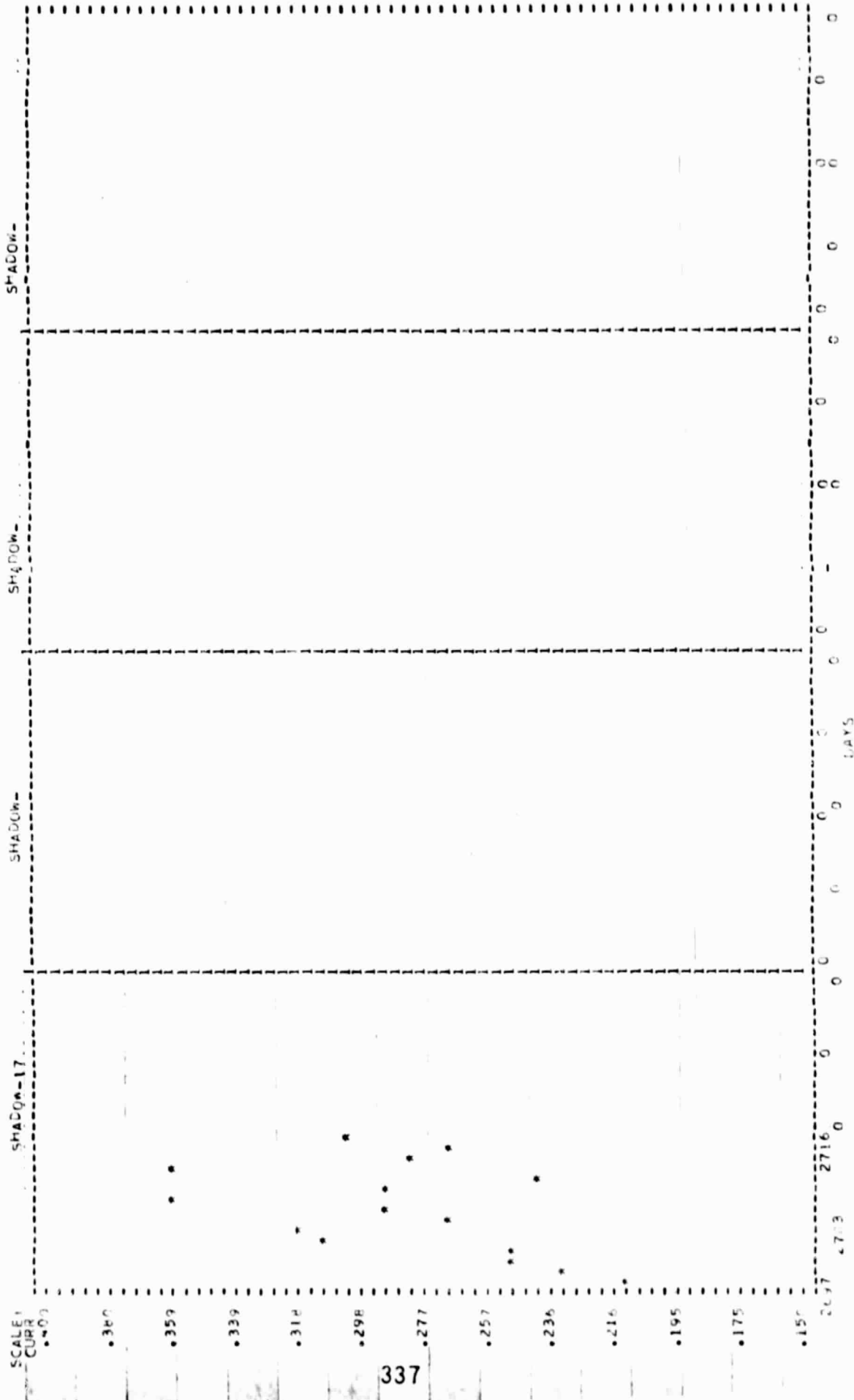
KEY: CHARGE CURRENT

DEPTH DISCHARGE 50
TEMPERATURE 12
AMPERE RATE 12
SERIAL 583 585 606 609 616

PROJECT ATS
GILTON CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 226A



2. Pack 226B, 5-cells

a. Cell information:

(1) Same as Pack 226A, Section V.H.1.a.(1) and (2)

(2) These cells were considered as flight cells as they were indicative of those cells which were launched in the ATS 6 satellite in May 1974. These cells were fabricated without electrolyte in 1971 and were stored dry in argon until they were activated in April 1973. They received acceptance tests at GSFC, 19.0 ah (25°C) and 15.5 ah (0°C), before being placed on a synchronous orbit test regime. The results of the first 4 eclipse seasons were reported in the Crane Report WQEC/C 77-134 of 9 June 1977.

3. The cells were fitted with pressure transducers prior to testing at NAVWPNSUPPCEN Crane.

b. Parameters:

| | | | |
|--------------------------|------|----------------------|-------|
| Depth of Discharge (%) | 50 | Voltage Limit (v/c) | 1.410 |
| Charge Control | VL | Temperature (°C) | 20 |
| Charge Current (amps) | 1.50 | Float Voltage (v/c)* | 1.410 |
| Discharge Current (amps) | 6.25 | | |

*--Current reduced to .25 ampere during sun period 7 due to pack overcharging.

LOAD SHARING--Two additional discharges (13% and 20% DOD at the 1 ampere rate) during each day, of shadows 3 and 4.

SITE EXPERIMENT SIMULATION--Two discharges (30% and 43% DOD at the 2 ampere rate) per day during the sun periods following shadows 3, 4 and 5.

c. Capacity Checks:

(1) Precycling and Shadow: (Discharge to .50 volts any cell or to an average of 1.00 volts per cell, whichever occurs first.)

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell
5 | ah
out |
|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Precycling | 18.8 | 18.8 | 18.8 | 19.0 | 18.9 | |
| Shadow 1 | .927 | 1.007 | .976 | 1.058 | .956 | 15.23 |
| Shadow 2 | .992 | .996 | .938 | 1.067 | .991 | 18.90 |
| Shadow 3** | .982 | .998 | .967 | 1.034 | 1.019 | 17.18 |
| Shadow 4** | .918 | .989 | .987 | 1.033 | 1.011 | 12.41 |
| Shadow 5 (Figure 277) | .929 | .996 | .991 | 1.026 | .991 | 10.58 |
| Shadow 6 (Figure 278) | .964 | .997 | .994 | 1.021 | .985 | 8.39 |
| Shadow 7 (Figure 279) | .983 | .982 | 1.014 | 1.016 | .944 | 13.49 |
| Shadow 8 (Figure 280) | 1.012 | 1.007 | 1.003 | 1.015 | .962 | 10.81 |
| Shadow 9 (Figure 281) | .959 | .997 | .990 | 1.009 | .988 | 11.44 |
| Shadow 10 (Figure 282) | 1.004 | .987 | .986 | 1.012 | .992 | 10.87 |
| Shadow 11 (Figure 283) | 1.014 | 1.009 | .996 | 1.019 | .973 | 10.39 |
| Shadow 12 (Figure 284) | 1.003 | 1.005 | .987 | 1.009 | .981 | 11.26 |
| Shadow 13 (Figure 285) | 15.21 | 15.15 | 15.21 | 17.31 | 14.90 | 111.61 |
| Post Cycling (Figure 285) | 15.05 | 15.05 | 15.30 | 15.30 | 15.05 | 141.31 |

**--Load sharing during shadows 3 and 4, and site experiment simulation prior to shadows 4, 5 and 6.

(2) Specials: (Discharge at 2.0 amperes to .75 volts any cell or to an average of 1.02 volts per cell, whichever occurs first.)

| | Cell
1 | Cell
2 | Cell
3 | Cell
4 | Cell
5 | ah
out |
|-----------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Special***cycle 639 | 1.006 | 1.021 | .974 | 1.057 | 1.034 | 16.23 |
| Special****cycle 773 | .984 | 1.016 | 1.013 | 1.054 | 1.028 | 14.16 |
| Special*****cycle 863 | .925 | 1.007 | 1.004 | 1.052 | 1.018 | 12.66 |

***--Prior to shadow 4, following 28 days on SITE EXPERIMENT SIMULATION.

****--Following shadow 4, after 3 days of float at VL.

*****--Following special capacity check, cycle 773 above, after 45 days on SITE EXPERIMENT SIMULATION.

d. Test results during the Shadow Periods: (Figures 287 to 295)

(1) End of Discharge Voltages: There was a significant decrease in these voltages during shadows 4, 5 and 6. This is attributed to the Site Experiment Simulation Test, conducted during the prior sun periods, as the EOD average voltage was 1.091 volts, at 43 percent DOD, the day prior to the start of shadow 6. The average voltages, the day before the capacity checks, were fairly constant beginning with shadow 8 (1.148 volts) through shadow 13 (1.145 volts). These shadows followed full sun periods in which the pack was on float at a constant current charge. The reconditioning effect, due to the capacity check, can be seen for each shadow.

(2) End of Charge Voltages and Recharge: Unbalanced voltages became noticeable at the beginning of shadow 7 in which there was a 10 mv difference between the high and low cell at EOC. This unbalance followed that sun period in which the pack was removed from float at its VL, due to an overcharging condition, and placed on a constant current charge. The cells were unbalanced at the start and end of each succeeding shadow except for the end of shadow 10 and the start of shadow 11. Significant increases in the amount of recharge corresponded to the first half of those shadow periods in which the cells were unbalanced.

(3) End of Charge Currents: Values began to increase at the start of shadow 3 due to the initiation of the load sharing test. The sudden drop in current (day 523) was due to the pack taken off the load sharing, for that day, because it had been discharged 5 hours too long the day before. The higher current values also corresponded to when the unbalance of the cells was maximum.

(4) Pressures at End of Charge: Pressure values remained at 0 psia for all cells during the first 3 shadow periods due to a hardware problem (loose wire on transducer excitation voltage). Pressures were in the range of 11 to 17 psia during the following shadow periods.

(5) The amperes hours out values, for shadows 3 and 4, did not include the ampere hours out during the load sharing discharges.

(6) The days listed following shadow 2 are not the actual calendar days (2355) the pack has been on test; as each discharge is considered a day for record keeping purposes, and this pack received 2 discharges a day during 3 sun periods.

(7) The pack was discontinued in the middle of shadow 13 in which each cell was discharged to .50 volts.

(8) Capacity Checks and Post Cycling: A decrease of 28 percent in capacity occurred between shadows 3 and 4 due to the Site Experiment Simulation Test initiated during the sun period between these 2 shadow periods. The increase from shadow 6 to 7 is due to this test being terminated prior to shadow 6. Average capacity, when the pack was discontinued to .50 v/c was 15.70 ah; but 25 percent of this was obtained below 1.00 v/c. Cell 4 exhibited the highest capacity throughout each capacity check. The average post cycling capacity to .50 v/c was 15.15 ah and only 5 percent was obtained below 1.00 v/c. The capacities obtained followed a 1.5 ampere charge for 22 hours at 20°C with a voltage limit of 1.410 v/c.

e. Performance during Sun Periods: The pack began test with a sun period and completed 13 of these periods. After one month, following shadow 3, the pack began a Site Experiment Simulation in which it received 2 discharges a day during the sun periods until period 7 when it was placed on float at its voltage limit of 1.410 v/c. After 4 months, the pack was placed on a constant current of .25 amperes when its voltage limit could not be maintained with a charge current of 1.50 amperes. Pressures during the first 4 periods were 0 psia; but this was due to a hardware problem. The range was 11 to 17 psia since period 5. Following is a listing of the high, average and low cell voltages and current (amps) at the start and end of sun periods 1 through 13.

Sun Periods

| | | | | 1 | 2 | 3 | 4 | | | | |
|-----------|--|--|--|--------------|------------|------------|------------|------------|--------------|------------|--------------|
| | | | | Start | End | Start | End | Start | End | Start | End |
| | | | | 1.411(2,4,5) | 1.414(5) | 1.412(5) | 1.413(5) | 1.412(5) | 1.412(2,3,5) | 1.412(5) | 1.412(2,3,5) |
| | | | | 1.410 | 1.411 | 1.410 | 1.409 | 1.412 | 1.411 | 1.409 | 1.411 |
| | | | | 1.408(1) | 1.410(1) | 1.408(3) | 1.403(1) | 1.411(1,3) | 1.407(1) | 1.407(1) | 1.409(1) |
| | | | | .22 | .33 | .53 | .49 | .58 | .53 | .53 | .57 |
| Voltages* | | | | | | | | | | | |
| High | | | | | | | | | | | |
| Average | | | | | | | | | | | |
| Low | | | | | | | | | | | |
| Current | | | | | | | | | | | |
| | | | | 5 | 6 | 7 | 8 | | | | |
| | | | | Start | End | Start | End | Start | End | Start | End |
| | | | | 1.411(3,4,5) | 1.410(2,5) | 1.413(5) | 1.391(1,4) | 1.390(1,2) | 1.397(4) | 1.390(1,2) | 1.397(4) |
| | | | | 1.410 | 1.409 | 1.410 | 1.386 | 1.386 | 1.391 | 1.386 | 1.391 |
| | | | | 1.409(1,2) | 1.408(3) | 1.408(4) | 1.380(5) | 1.379(5) | 1.386(3) | 1.379(5) | 1.386(3) |
| | | | | .65 | .57 | .43 | .25 | .48 | .25 | .25 | .25 |
| Voltages | | | | | | | | | | | |
| High | | | | | | | | | | | |
| Average | | | | | | | | | | | |
| Low | | | | | | | | | | | |
| Current | | | | | | | | | | | |
| | | | | 9 | 10 | 11 | 12 | | | | |
| | | | | Start | End | Start | End | Start | End | Start | End |
| | | | | 1.390(1) | 1.389(4) | 1.404(2,4) | 1.390(4) | 1.404(5) | 1.394(5) | 1.404(5) | 1.394(5) |
| | | | | 1.382 | 1.382 | 1.403 | 1.383 | 1.398 | 1.389 | 1.401 | 1.391 |
| | | | | 1.376(3) | 1.375(3) | 1.401(3) | 1.380(3) | 1.396(3) | 1.386(3) | 1.400(2,4) | 1.386(3) |
| | | | | .25 | .25 | .25 | .25 | .25 | .25 | .25 | .25 |
| Voltages | | | | | | | | | | | |
| High | | | | | | | | | | | |
| Average | | | | | | | | | | | |
| Low | | | | | | | | | | | |
| Current | | | | | | | | | | | |

Sun Periods (cont.)

| 13 | |
|-----------|----------------------|
| Voltages* | Start End |
| High | 1.404(1) 1.398(5) |
| Average | 1.400 1.394 |
| Low | 1.395(5) 1.390(3) |
| Current | .25 |

*--() indicates which cell.

Note: End values on periods 4, 5 and 6 are at completion of Site Experiment Simulation cycle.

f. Cell Analysis:

(1) The following photograph shows the condition of the plates and separator of cell 1 as it was opened at Crane following completion of 12.5 shadow periods.

(2) Cells 2, 3, 4 and 5 were returned to GSFC.

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PACK 226B

CELL C-1

Pack 226B, Cell 1, 12.5 shadow periods
at 50 percent DOD, 20°C: Slight dampness
with severe migration and separator
deterioration.

PHOTOGRAPH 5

344

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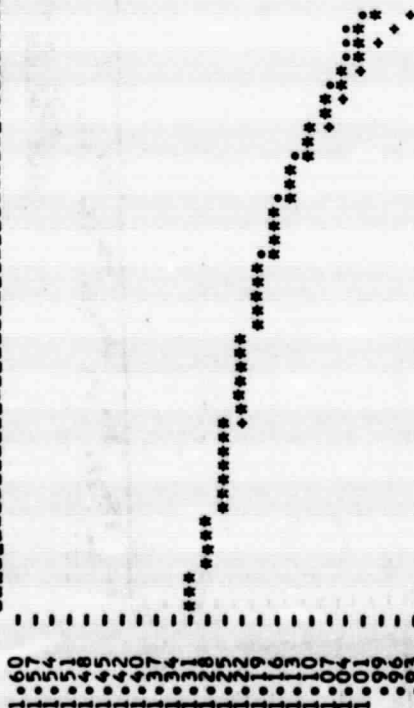
PACK NUMBER IS 2268
SHARD NUMBER IS 001508
CYCLE NUMBER IS 1019
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

.25 1.74 3.21 4.69 6.16 7.64 9.11 10.58
.99 2.48 3.95 5.43 6.90 8.38 9.85

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 16. 23. 30. 37. 44. 52. 59. 66. 73. 80. 88. 95. 103.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 277

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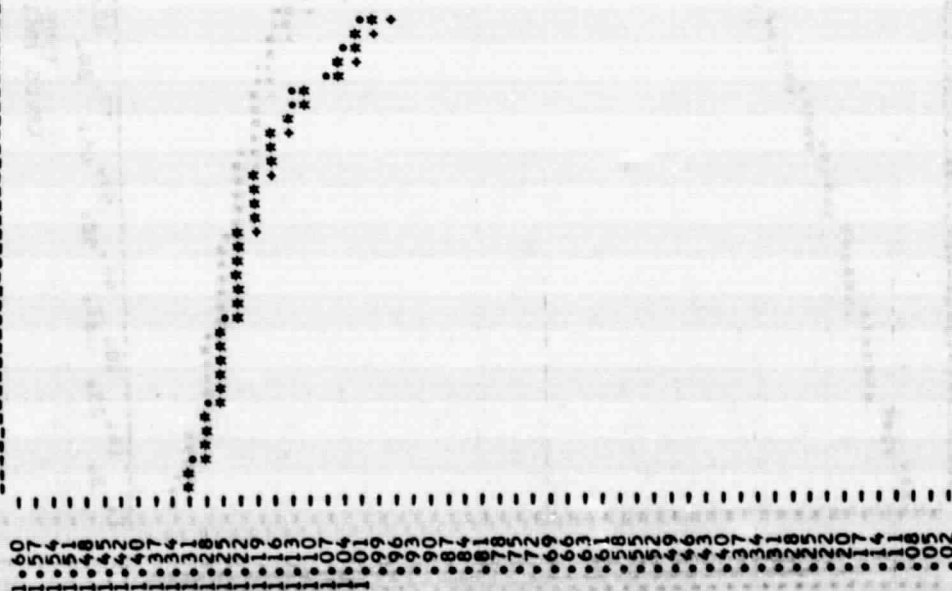
PACK NUMBER IS 2268
SHADOW PERIOD IS 06
CYCLE NUMBER IS 1304
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

0.25 1.74 3.22 4.70 6.17 7.65
1.00 2.48 3.96 5.43 6.91 8.39

C A P A C I T Y C E L L V O L T A G E S C A L E



1. 8. 15. 22. 31. 44. 58. 73. 81.

TIME IN MINUTES
CELLS INCLUDED V1 V2 V3 V4 V5

FIGURE 278

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KEY
• HIGH CELL
• LOW CELL
• AVERAGE

PACK NUMBER IS 2268
SHADOW PERIOD IS 07
CYCLE NUMBER IS 1492
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

.25 1.72 3.17 4.63 6.08 7.53 9.01 10.49
.98 2.45 3.90 5.36 6.81 8.27 9.75

C A P A C I T Y C E L L V O L T A G E S C A L E

1.60
1.57
1.54
1.51
1.48
1.45
1.42
1.39
1.36
1.33
1.30
1.27
1.24
1.21
1.18
1.15
1.12
1.09
1.06
1.03
1.00
0.97
0.94
0.91
0.88
0.85
0.82
0.79
0.76
0.73
0.70
0.67
0.64
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.19
0.16
0.13
0.10
0.07
0.04
0.01
0.00

1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 279

PACK NUMBER IS 2268
SHADOW PERIOD IS 08
CYCLE NUMBER IS 01630
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

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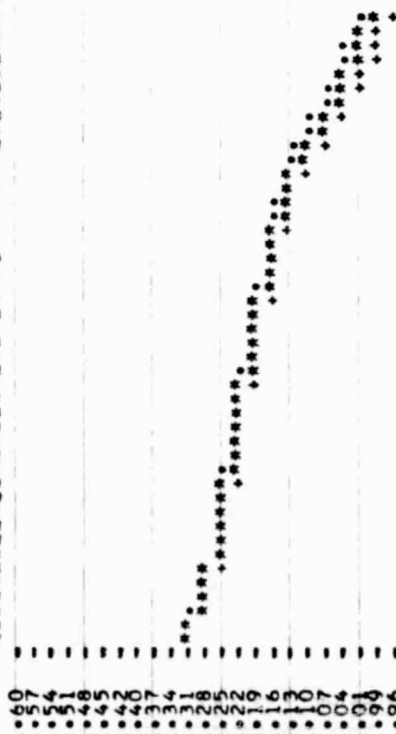
KEY HIGH CELL
• LOW CELL
• AVERAGE

1. 1.66 3.11 4.56 6.00 7.45 8.89 10.33 10.80
.93 2.39 3.84 5.28 6.73 8.17 9.61

C
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L
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G
E

S
C
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E



1. 8. 15. 22. 29. 37. 44. 51. 59. 65. 73. 80. 87. 94. 101. 106.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 280

PACK NUMBER IS 226B
SHADOW PERIOD IS 9
CYCLE NUMBER IS 1813
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

06 1.55 3.04 4.52 6.00 7.48 8.97 10.46 11.44
81 2.30 3.78 5.26 6.74 8.22 9.71 11.20

C A P A C I T Y C E L L V O L T A G E S C A L E



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1. 8. 16. 22. 29. 37. 44. 51. 58. 65. 73. 80. 87. 94. 101. 109. 111.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 281

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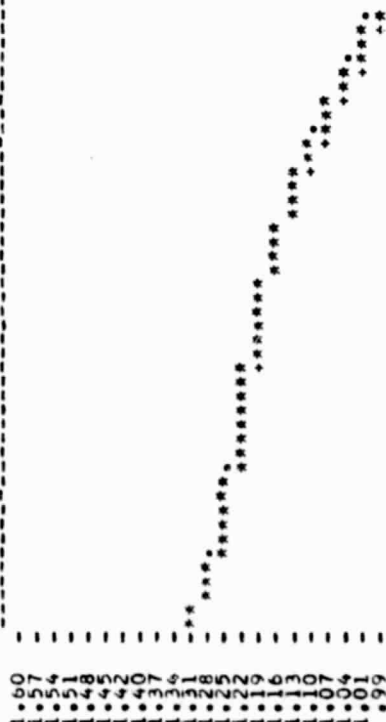
PACK NUMBER IS 226B
SHADOW PERIOD IS 10
CYCLE NUMBER IS 1-93
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

1. 8. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 87. 95. 102. 108.
.88 2.40 3.15 4.65 5.39 6.14 7.64 8.38 9.88

C A P A C I T Y C E L L V O L T A G E S C A L E



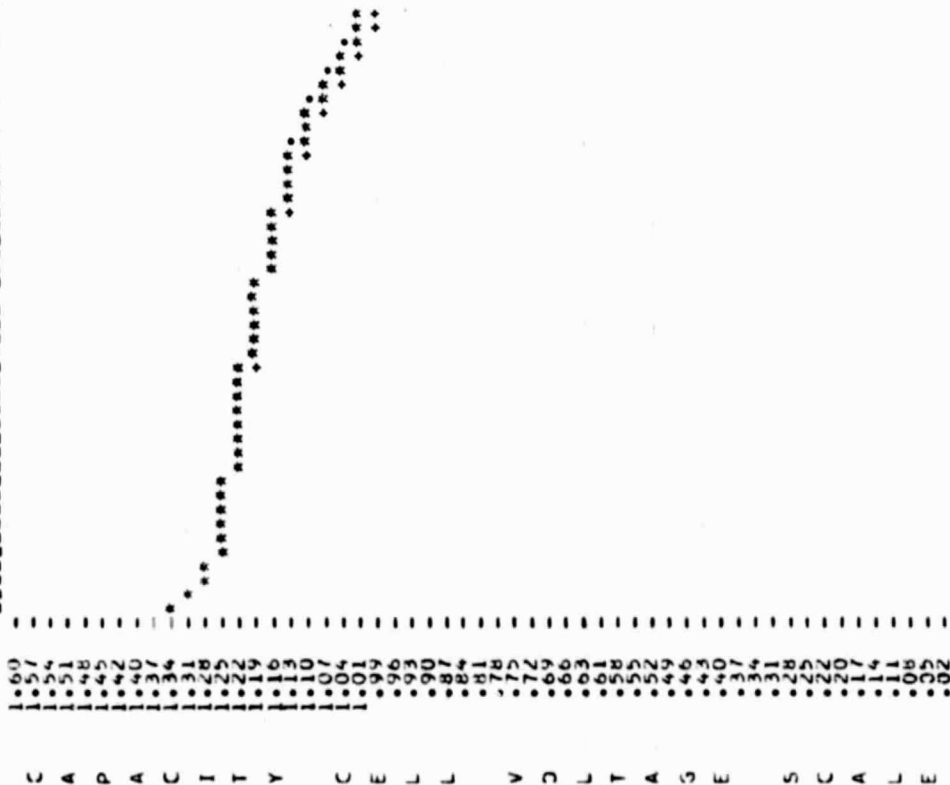
TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 282

PACK NUMBER IS 226B
 SHADOW PERIOD IS 11
 CYCLE NUMBER IS 2176
 DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY HIGH CELL
 * LOW CELL
 * AVERAGE



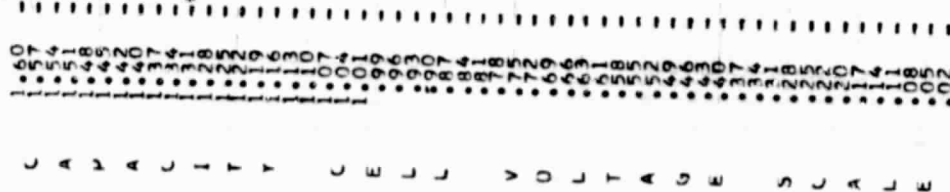
TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 283

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AMPERE HOUR OUT

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| | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|------|
| 1. | 16. | 30. | 45. | 59. | 73. | 88. | 102. |
| 9. | 23. | 37. | 52. | 66. | 81. | 95. | 109. |

| TIME IN MINUTES | | CELLS INCLUDED | | | | |
|-----------------|---|----------------|-----|-----|-----|-----|
| | | V-1 | V-2 | V-3 | V-4 | V-5 |
| 1 | 1 | | | | | |
| 2 | 1 | | | | | |
| 3 | 1 | | | | | |
| 4 | 1 | | | | | |
| 5 | 1 | | | | | |
| 6 | 1 | | | | | |
| 7 | 1 | | | | | |
| 8 | 1 | | | | | |
| 9 | 1 | | | | | |
| 10 | 1 | | | | | |
| 11 | 1 | | | | | |
| 12 | 1 | | | | | |
| 13 | 1 | | | | | |
| 14 | 1 | | | | | |
| 15 | 1 | | | | | |
| 16 | 1 | | | | | |
| 17 | 1 | | | | | |
| 18 | 1 | | | | | |
| 19 | 1 | | | | | |
| 20 | 1 | | | | | |
| 21 | 1 | | | | | |
| 22 | 1 | | | | | |
| 23 | 1 | | | | | |
| 24 | 1 | | | | | |
| 25 | 1 | | | | | |
| 26 | 1 | | | | | |
| 27 | 1 | | | | | |
| 28 | 1 | | | | | |
| 29 | 1 | | | | | |
| 30 | 1 | | | | | |
| 31 | 1 | | | | | |
| 32 | 1 | | | | | |
| 33 | 1 | | | | | |
| 34 | 1 | | | | | |
| 35 | 1 | | | | | |
| 36 | 1 | | | | | |
| 37 | 1 | | | | | |
| 38 | 1 | | | | | |
| 39 | 1 | | | | | |
| 40 | 1 | | | | | |
| 41 | 1 | | | | | |
| 42 | 1 | | | | | |
| 43 | 1 | | | | | |
| 44 | 1 | | | | | |
| 45 | 1 | | | | | |
| 46 | 1 | | | | | |
| 47 | 1 | | | | | |
| 48 | 1 | | | | | |
| 49 | 1 | | | | | |
| 50 | 1 | | | | | |
| 51 | 1 | | | | | |
| 52 | 1 | | | | | |
| 53 | 1 | | | | | |
| 54 | 1 | | | | | |
| 55 | 1 | | | | | |
| 56 | 1 | | | | | |
| 57 | 1 | | | | | |
| 58 | 1 | | | | | |
| 59 | 1 | | | | | |
| 60 | 1 | | | | | |
| 61 | 1 | | | | | |
| 62 | 1 | | | | | |
| 63 | 1 | | | | | |
| 64 | 1 | | | | | |
| 65 | 1 | | | | | |
| 66 | 1 | | | | | |
| 67 | 1 | | | | | |
| 68 | 1 | | | | | |
| 69 | 1 | | | | | |
| 70 | 1 | | | | | |
| 71 | 1 | | | | | |
| 72 | 1 | | | | | |
| 73 | 1 | | | | | |
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| 75 | 1 | | | | | |
| 76 | 1 | | | | | |
| 77 | 1 | | | | | |
| 78 | 1 | | | | | |
| 79 | 1 | | | | | |
| 80 | 1 | | | | | |
| 81 | 1 | | | | | |
| 82 | 1 | | | | | |
| 83 | 1 | | | | | |
| 84 | 1 | | | | | |
| 85 | 1 | | | | | |
| 86 | | | | | | |

FIGURE 284

PACK NUMBER IS 2208
SHADOW PERIOD IS 13
CYCLE NUMBER IS 2542
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

KEY HIGH CELL
LOW CELL
AVERAGE

25 1.75 3.25 4.72 6.19 7.67 9.14 10.61 12.12 13.63 15.14 16.69 17.31
1.00 2.49 3.98 5.46 6.93 8.40 9.87 11.36 12.87 14.39 15.90 17.06

C 1.59
A 1.54
P 1.48
A 1.42
C 1.37
I 1.32
T 1.27
Y 1.22
C 1.17
E 1.12
L 1.07
V 1.02
O 0.97
J 0.92
T 0.87
A 0.82
S 0.77
C 0.72
A 0.67
L 0.62
E 0.57
S 0.52
C 0.47
A 0.42
L 0.37
E 0.32
S 0.27
C 0.22
A 0.17
L 0.12
E 0.07
S 0.02

353

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1. 8. 15. 30. 44. 51. 58. 65. 73. 87. 101. 116. 131. 145. 164. 173.
22. 37. 51. 65. 79. 94. 109. 123. 137. 152. 171.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 285

PACK NUMBER IS 226B
POST CYCLING IS 2543
DISCHARGE RATE IS 6.25

AMPERE HOUR OUT

06 1.20 2.70 4.18 5.67 7.15 8.63 10.12 11.60 13.08 14.56 15.20
45 1.95 3.44 4.93 6.41 7.89 9.38 10.86 12.34 13.82 15.05

C
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1. 8. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 87. 95. 102. 110. 116. 123. 131. 138. 145. 152. 159.

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 286

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
GULTON CELLS

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
• HIGH END DISCHARGE VOLTAGE
• AVE END DISCHARGE VOLTAGE
• LOW END DISCHARGE VOLTAGE
• HIGH EUC
• AVE EUC
• LOW EUC

SERIAL 714 715 723 740 741
PROJECT ATS

PACK = 226d

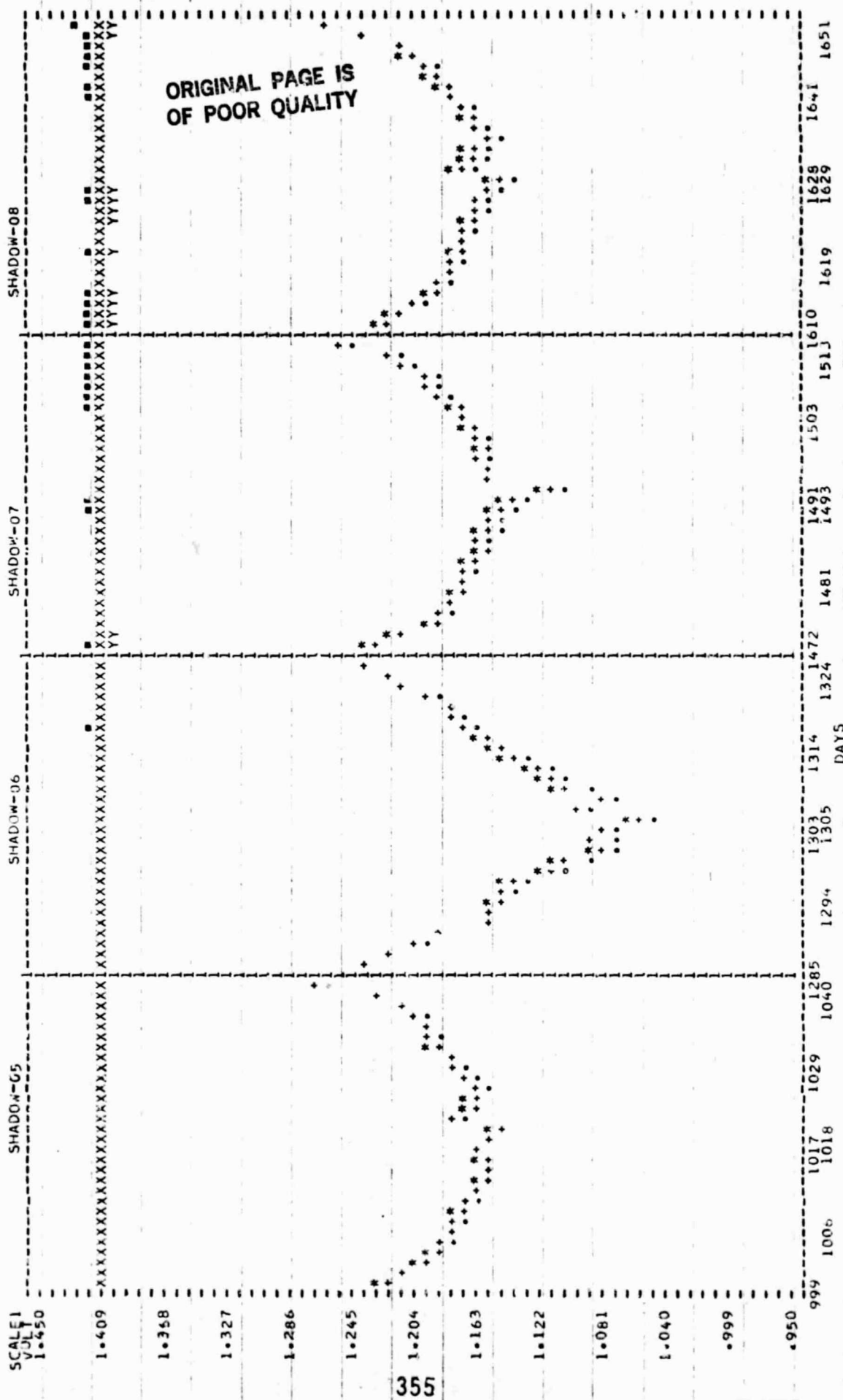


FIGURE 287

DEPTH DISCHARGE 50 WQEC/C 81-120A
 TEMPERATURE 20
 AMPERE RATE 15
 GULTON CELLS

SERIAL 714 715 723 740 741
 PROJECT ATS

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
 * HIGH DISCHARGE VOLTAGE
 + LOW DISCHARGE VOLTAGE
 x HIGH POC
 y LOW POC

PACK = 224M

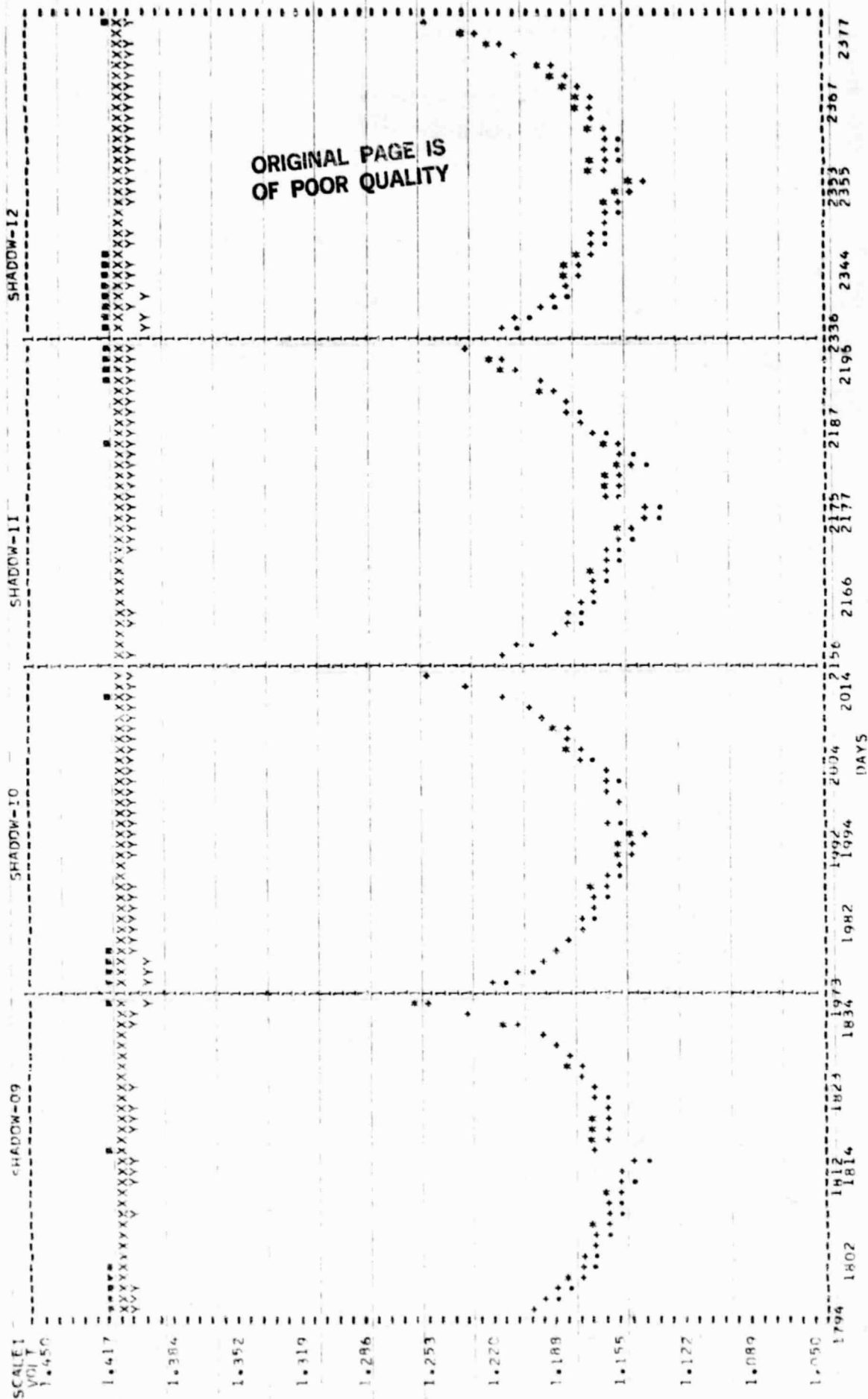


FIGURE 288

* A/C
* AH1-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

W400/C 81-120A

50

DEPTH CHANGE
TEMPERATURE 20
AMPERE RATE 15

GULFON CELLS
SERIAL 714 715 723 740 741
PROJECT ATS

PACK = 226B

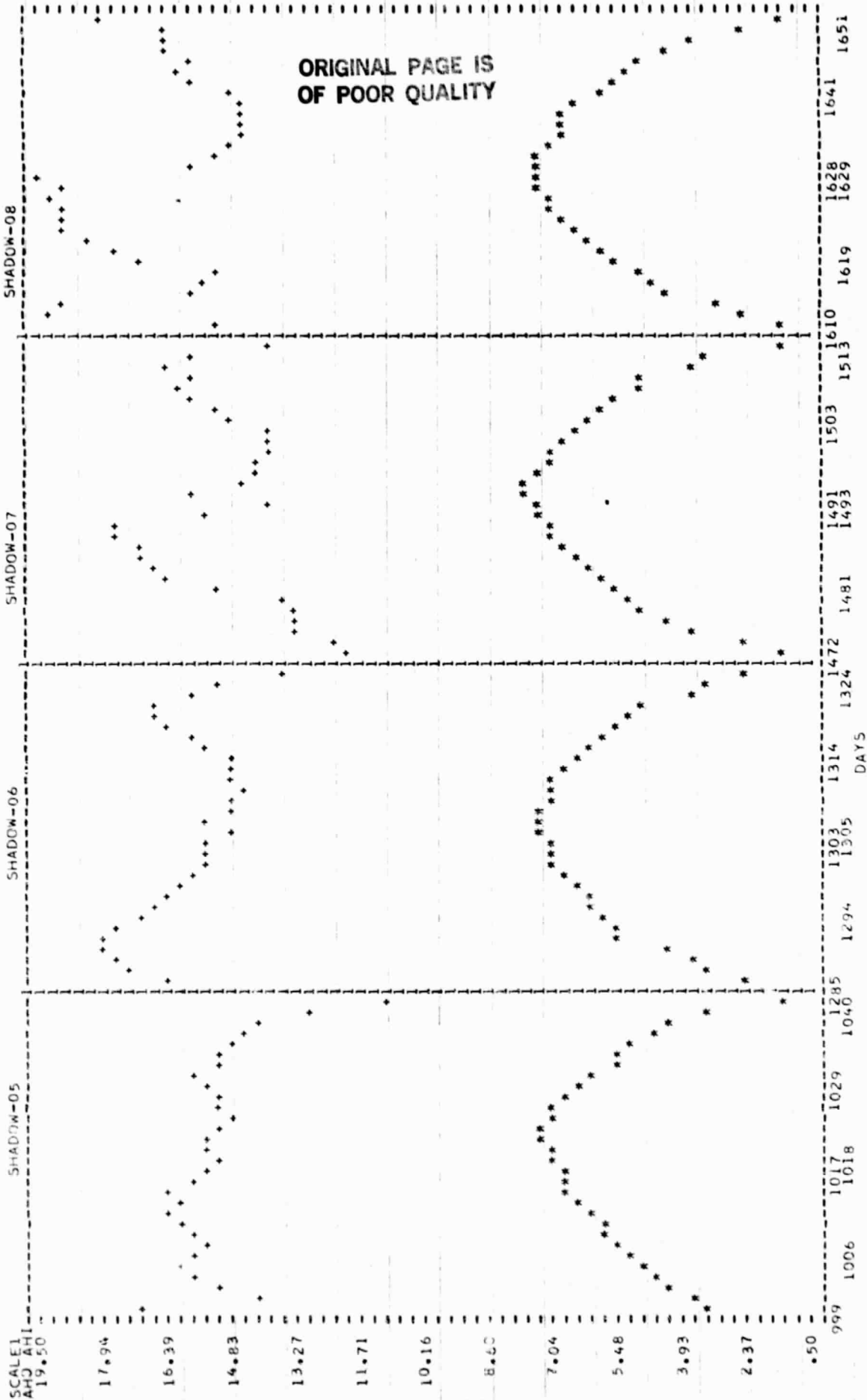


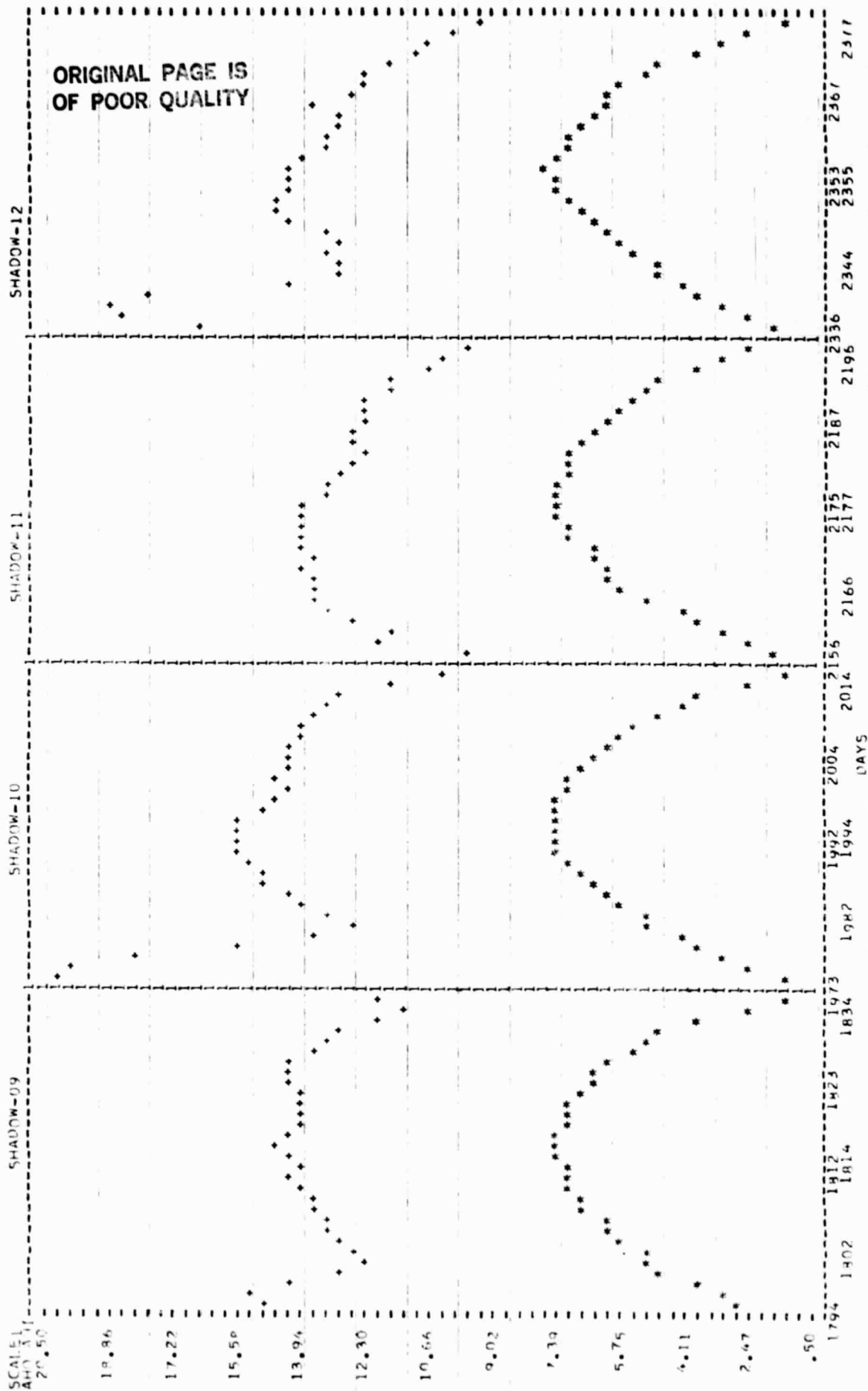
FIGURE 290

KEY
 * AVO
 * AVE-TOTAL

DEPTH DISCHARGE 50
 TEMPERATURE 20
 AMPERE RATE 15
 GULFON CELLS
 SERIAL 742 / 15 723 740 741
 PROJECT AT5

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 226H



KEY
* AHQ
+ AHQ-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
GULLION CELLS
SERIAL 714 715 723 740 741
PROJECT ATS

PACK = 226B

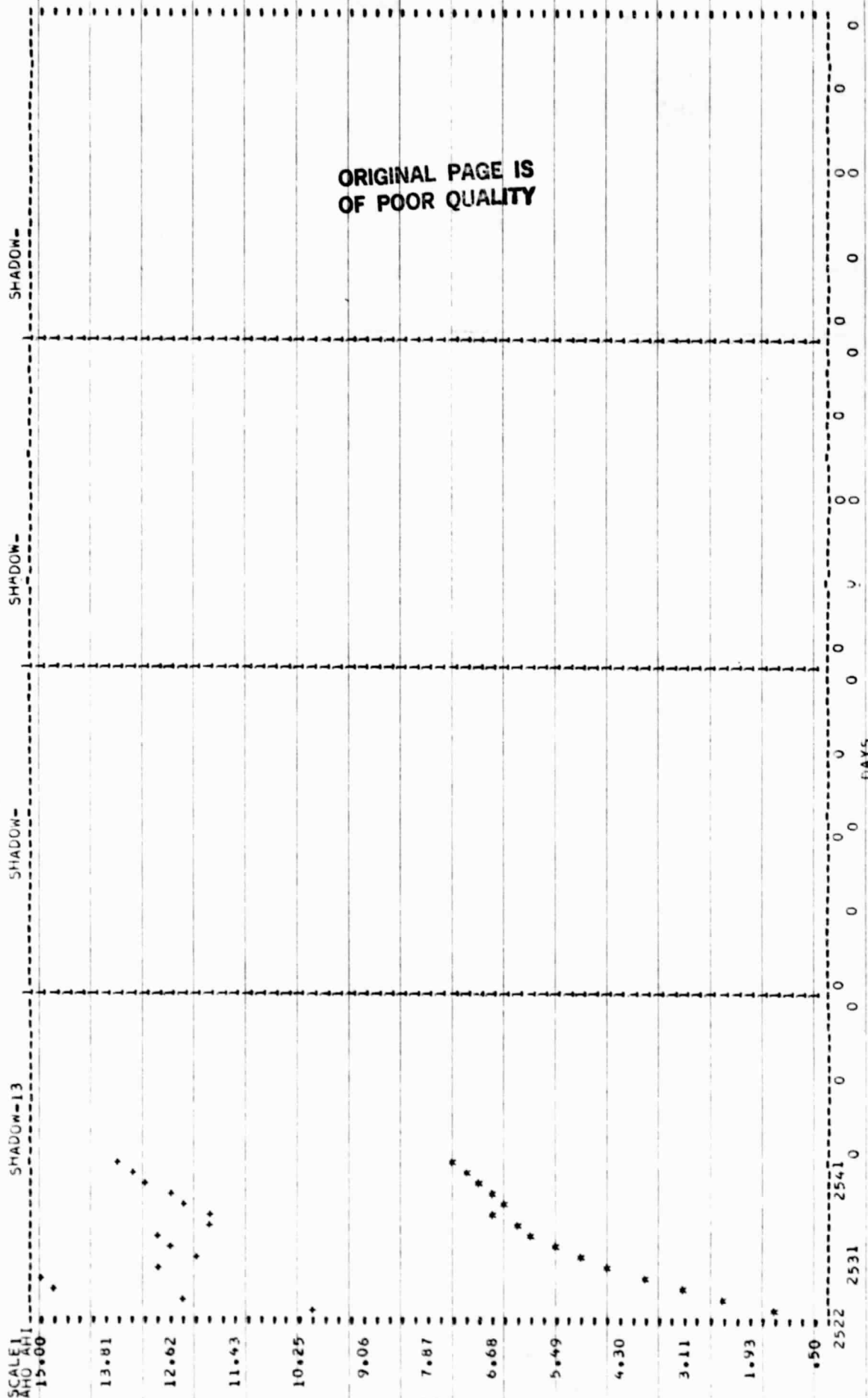


FIGURE 292

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
SERIAL 714 715 723 740 741

PROJECT AT'S
GULTON CELLS

PACK = 226B

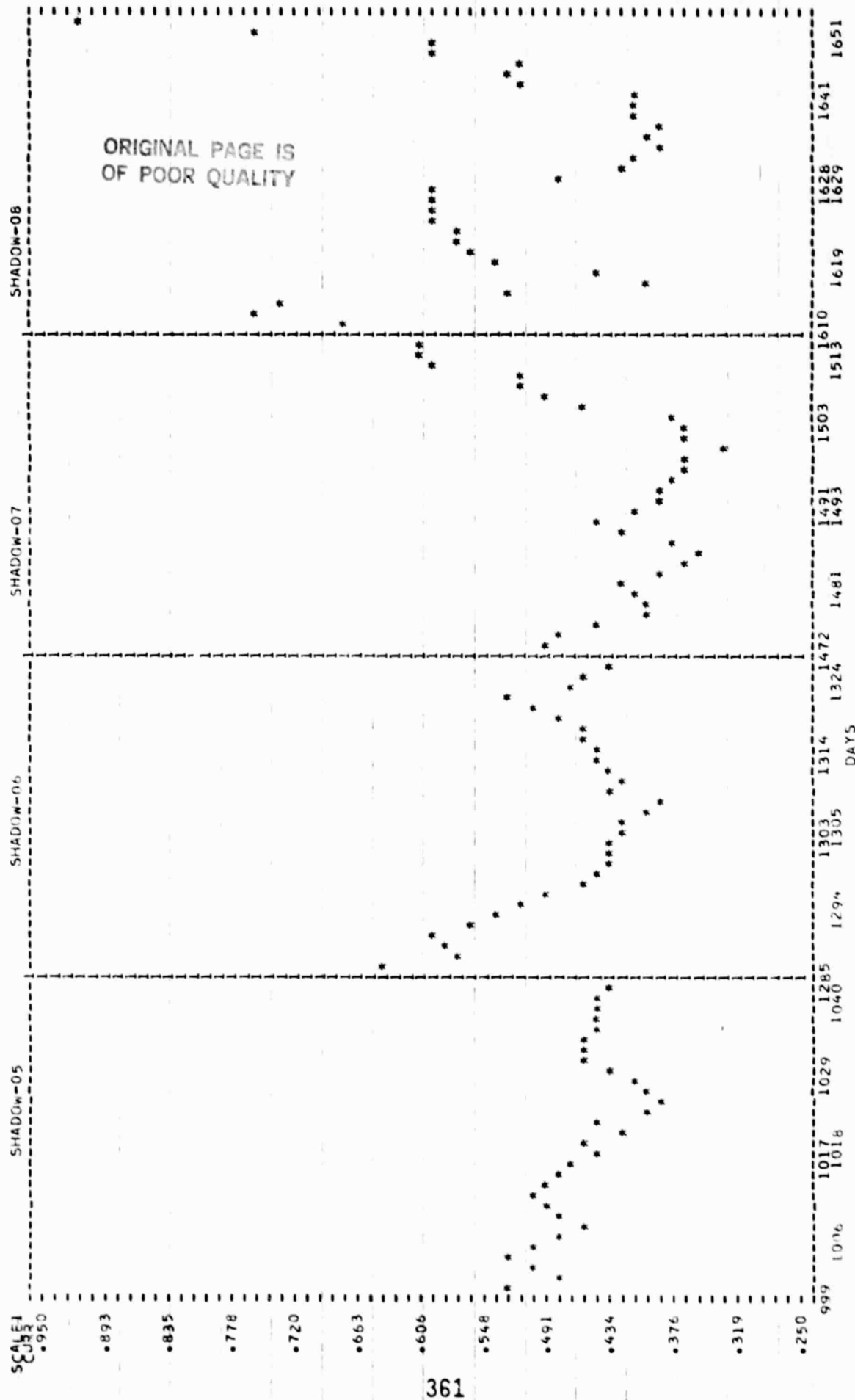


FIGURE 293

KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

WQEC/C 81-120A

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
SERIAL 714 715 723 740 741

PROJECT ATS
GULTON CELLS

PACK = 226H

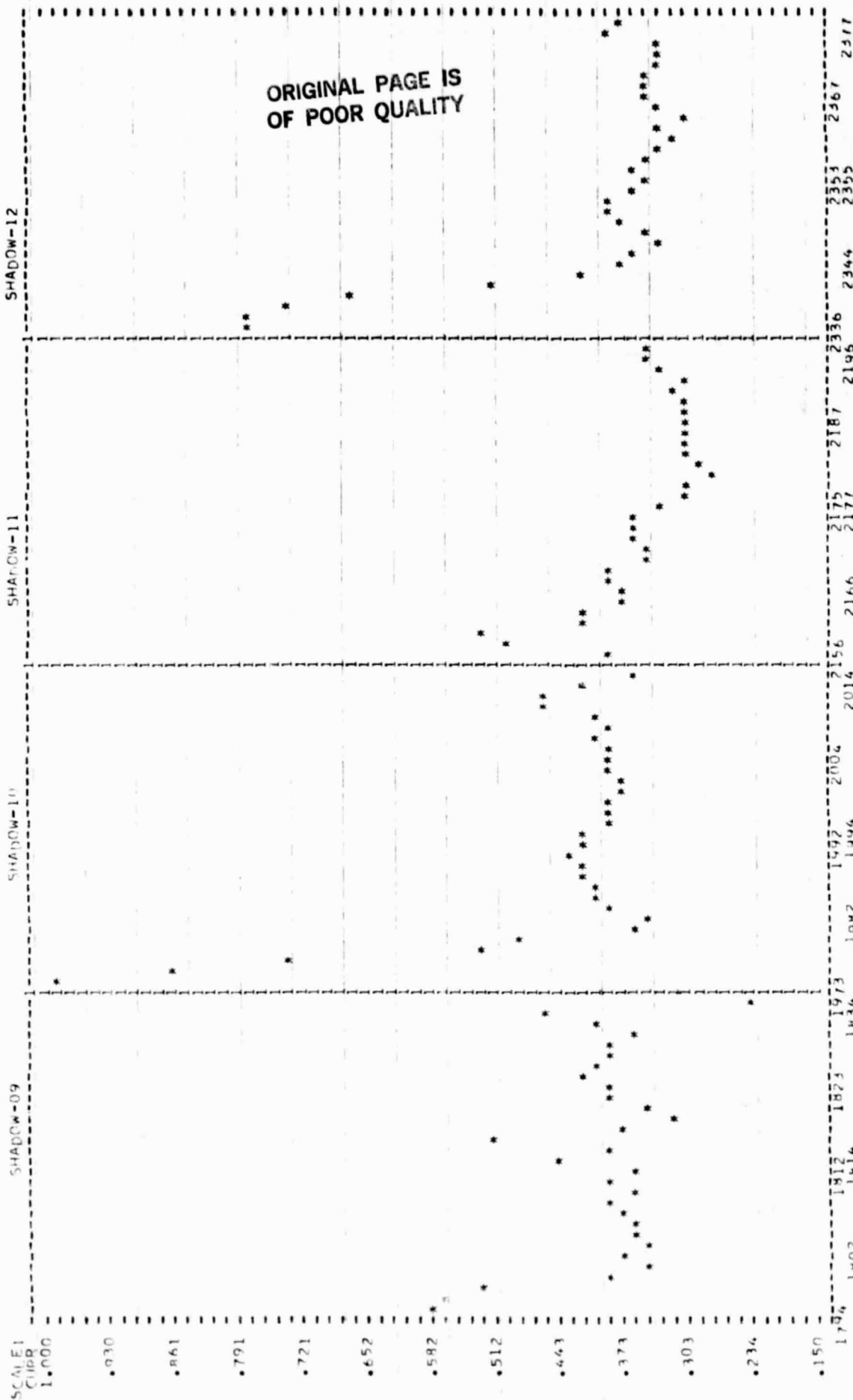


FIGURE 294

KEY
* TWO VOLTAGE CURRENT

MOEC/C 81-120A

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50
TEMPERATURE 20
AMPERE RATE 15
SERIAL 714 715 723 740 741
PROJECT ATS
GILTON CELLS

PACK = 224P
SHADOW

SHADOW-13

SCALE
CURR
500

471

441

414

385

357

328

299

270

242

213

184

156

2531 2541 0

DAYS

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I. EP 20.0 ah

1. Pack 229C, 5-cells

a. Cell information:

(1) These cells did not meet GSFC's requirements as a standard cell. The cells were manufactured for NASA, GSFC, under NASA contract number NAS 5-22461 according to the manufacturer's Manufacturing Control Document (MCD) RSN20, whose design was intended to meet the requirements of GSFC's specification 74-15000 with amendments. The cells were identified by the manufacturer's number RSN20-3 with one cell having an auxiliary electrode. Cell 2 was fitted with a pressure transducer prior to testing. Initial evaluation test results are contained in NAVWPNSUPPCEN Crane Report WQEC/C 79-144. Cells, of this type, were evaluated on near-earth orbit test regimes.

b. Parameters:

| | | | |
|-----------------------------|-------|----------------------|-----|
| Depth of Discharge (%) | 60 | Temperature (°C) | 20 |
| Charge Control ¹ | VL | Float Current (amps) | .33 |
| Charge Current (amps) | 2.00 | Auxiliary Electrode* | |
| Discharge Current (amps) | 10.00 | Resistance (ohms) | 47 |
| Voltage Limit (v/c) | 1.414 | | |

*--Cell 5

c. Capacity Checks: (Discharge each cell to .75 volts)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Precycling (Figure 296) | .190 | .473 | .318 | .139 | 1.134 | 23.87 |
| Shadow 1 (Figure 297) | | | | | 26.07 | |
| Shadow 2 (Figure 298) | | | | 27.95 | 27.55 | |
| Shadow 3 (Figure 299) | | | 28.56 | 27.96 | 27.96 | |
| Shadow 4 (Figure 300) | | 27.52 | 27.22 | 27.52 | 27.32 | |
| Shadow 5 (Figure 301) | 27.91 | 25.74 | 26.64 | 27.12 | 27.12 | |
| Shadow 6 (Figure 302) | | | | | 26.79 | |

d. Test results during the Shadow Periods: (Figures 303 to 308)

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.206 (shadow 1) to 1.174 volts (shadow 5) before it was capacity checked, with the largest decrease (19 mv) being from shadow 1 to 2. The reconditioning effect on those cells, which are capacity checked, is only slightly noticeable from one mid-shadow to another. Cell 1's mid-shadow voltage increased 4 mv from shadow 5, when it received its first capacity check, to shadow 6. The mid-shadow voltage of cell 5, which receives a capacity check each shadow, was 1.181 volts the last shadow and has decreased 1 to 2 mv each of the three previous shadows. The decrease in voltages, the day following the capacity checks, is due to those cells being on open-circuit for 24 hours during these checks.

(2) Capacity/Reconditioning Effects: The capacity of cell 5 increased from 26.07 (shadow 1) to 27.96 ah (shadow 3) and then decreased to 26.79 ah the last shadow. Also, this cell has not had any voltage degradation to 1.10 or 1.00 volts when comparing the capacity checks of shadow 1 with shadow 6. The other cells, when comparing their first and last capacity checks, do indicate slight degradation in capacity and voltage; but they would have had the same results as cell 5 if their capacity check schedule would have been the same. The input, prior to the capacity checks, has always been greater than 31 ah. The discharge voltages of those cells, which are capacity checked, have increased 34 to 45 mv the day following these checks with the less frequent checked cells having the greatest increase. The reconditioning effect, due to the daily discharges, is obvious from the graphs as the values for the low end discharge voltages are higher during the second half of the shadows.

(3) End of Charge Voltages and Pressures: The cells have been balanced, 2 to 3 mv difference between the high and low cells, only during the second half of shadow 2 and the first 7 days of shadow 3. During the last shadow, there was an 11 mv difference at mid-shadow. The mid-shadow pressure (cell 2) was 21 psia during shadow 1 and has ranged from 9 to 13 psia during the other shadows.

(4) Ampere-Hour Input: The mid-shadow input has ranged from 31.9 ah (shadow 3), with the pack temperature during charge not exceeding 22.8°C, to 39.1 ah (shadow 2) with the peak pack temperature being 27°C. Maximum input was during the second half of shadow 2 when the cells were balanced at EOC. The pack's temperature exceeded 25°C during the first half of shadow 1 and it was assured, at this time, that the pack's position in the environmental chamber was receiving the proper air circulation.

e. Performance during Sun Period: Pack has completed 5 sun periods as it began test with a shadow period. The pressure has not exceeded 13 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period.

| Voltages** | 1 | | 2 | | 3 | |
|------------|---------------|-----------|-----------|-------------|-----------|-------------|
| | Start | End | Start | End | Start | End |
| High | 1.384 (3,4,5) | 1.399 (4) | 1.389 (3) | 1.399 (3,4) | 1.395 (4) | 1.405 (1,4) |
| Average | 1.383 | 1.396 | 1.388 | 1.398 | 1.393 | 1.403 |
| Low | 1.381 (2) | 1.394 (2) | 1.382 (2) | 1.396 (5) | 1.391 (2) | 1.401 (3,5) |

| Voltages | 4 | | 5 | |
|----------|-------------|-----------|-----------|-----------|
| | Start | End | Start | End |
| High | 1.378 (1,4) | 1.396 (1) | 1.387 (4) | 1.404 (3) |
| Average | 1.376 | 1.392 | 1.384 | 1.397 |
| Low | 1.372 (2) | 1.386 (5) | 1.381 (1) | 1.393 (5) |

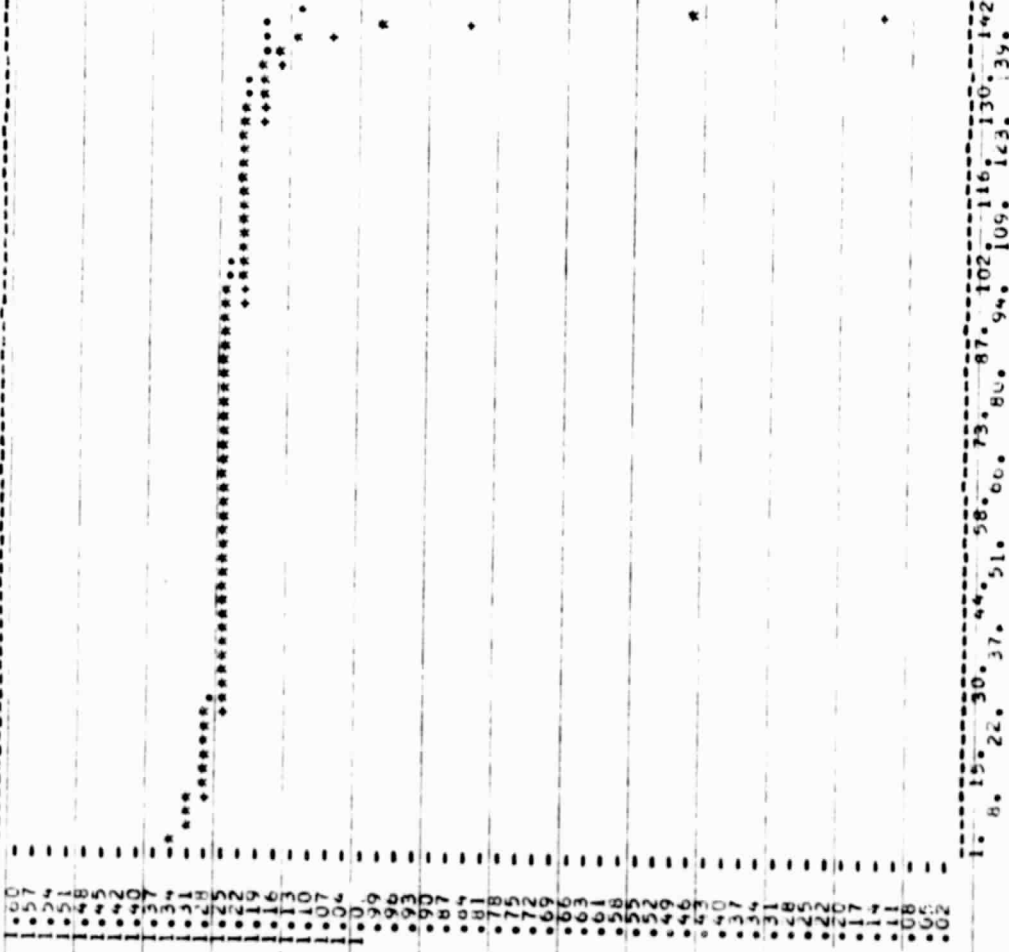
**--() indicates which cell

PACK NUMBER IS 229C
PRE-CYCLING
CYCLE NUMBER IS 10
DISCHARGE RATE IS 1.0

AMPERE HOUR OUT

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

10 2.48 4.09 7.31 9.74 15.19 17.58 17.01 19.73 21.85 23.07
1.29 3.67 6.10 8.53 10.95 13.37 15.80 18.22 20.64 23.06



CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 296

KEY
• HIGH CELL
♦ LOW CELL
■ AVERAGE

PACK NUMBER IS 229C
SHADOW NUMBER IS 15 02
CYCLE NUMBER IS 100
DISCHARGE IS 100

AMPERE HOUR OUT

0.00 2.42 4.83 7.22 9.62 12.01 14.41 16.80 19.19 21.59 23.98 26.36 27.95
1.21 3.62 6.02 8.42 10.82 13.21 15.60 18.00 20.39 22.78 25.17 27.55

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| | | | | | | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| 1. | 15. | 30. | 44. | 59. | 73. | 87. | 102. | 116. | 131. | 145. | 159. | 171. |
| 1. | 8. | 23. | 37. | 51. | 66. | 81. | 95. | 109. | 123. | 138. | 152. | 167. |

TIME IN MINUTES
CELLS INCLUDED V-4 V-5

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229C
 S-A-D-O-A PERIOD IS 03
 CYCLE NUMBER IS 387
 DISCHARGE RATE IS 10.

WDEC/C 81-120A

AMPERE HOUR OUT

30 2.70 5.09 7.48 9.87 12.25 14.64 17.03 19.42 21.80 23.92 26.37 28.56
 1.56 3.95 6.29 8.68 11.06 13.45 15.84 18.22 20.61 22.80 25.18 27.56

C A P A C I T Y C E L L V O L T A G E S C A L E
 00
 01
 02
 03
 04
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1. 8. 15. 23. 30. 37. 44. 51. 60. 66. 73. 80. 87. 95. 102. 109. 116. 123. 130. 138. 145. 152. 159. 167. 174. 183.

TIME IN MINUTES
 CELLS INCLUDED V-3 V-4 V-5

FIGURE 299

ANDREFF -0.00 0.7

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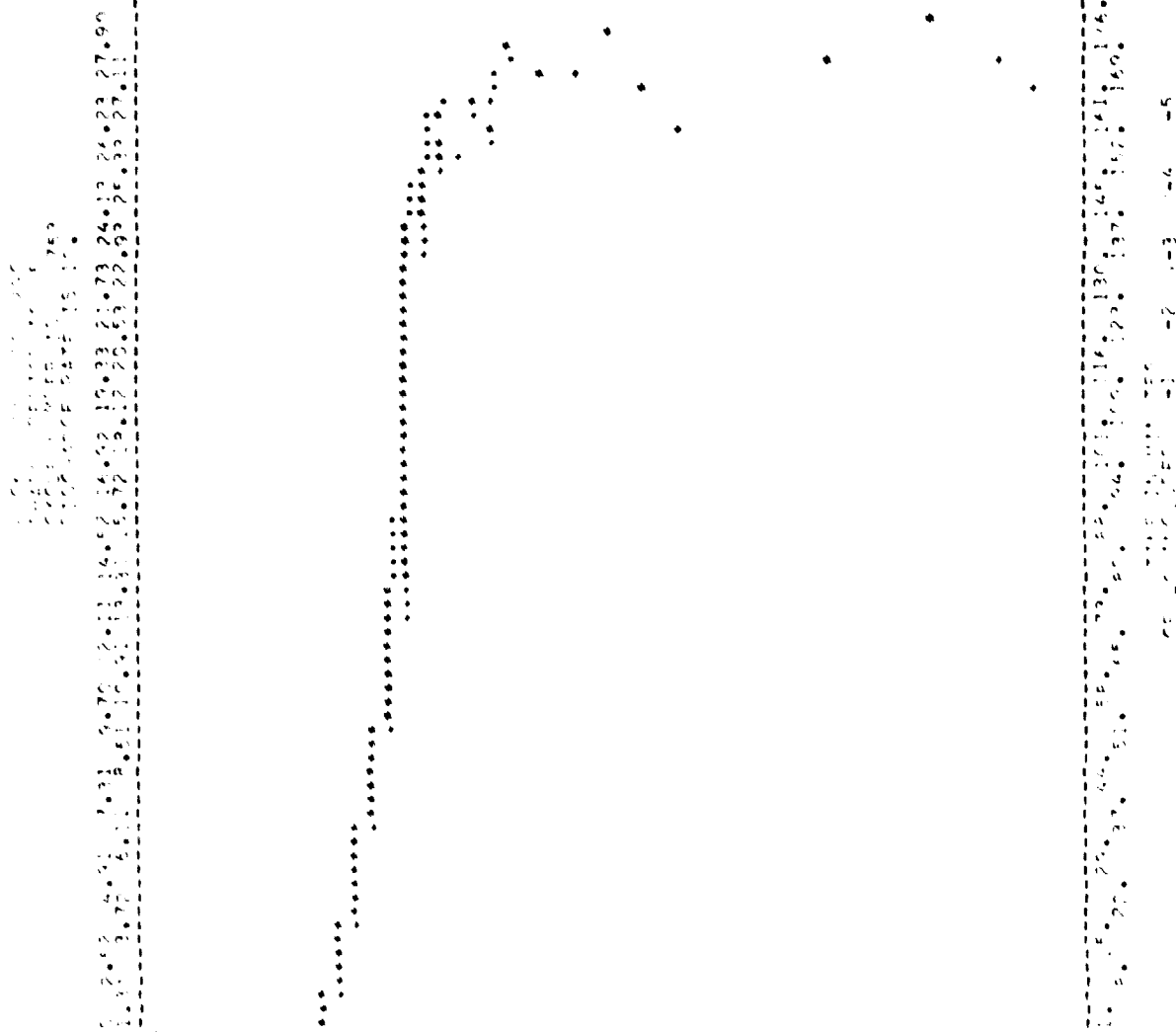


FIGURE 301

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AUDISE DATE 20
 EAGLE-PICHER C

PROJECT 1
 SERIAL 90.98.94.96.82

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 229C

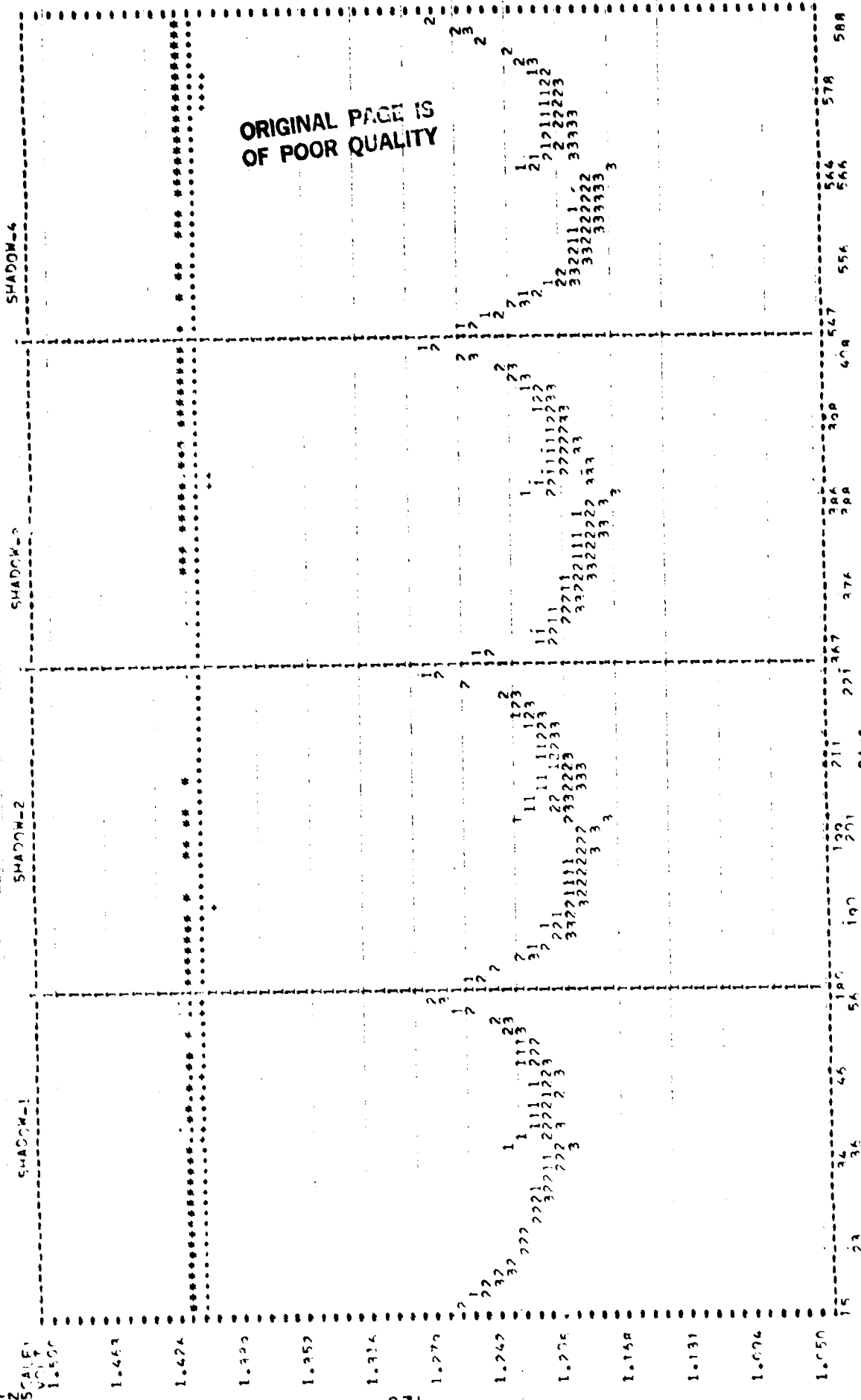


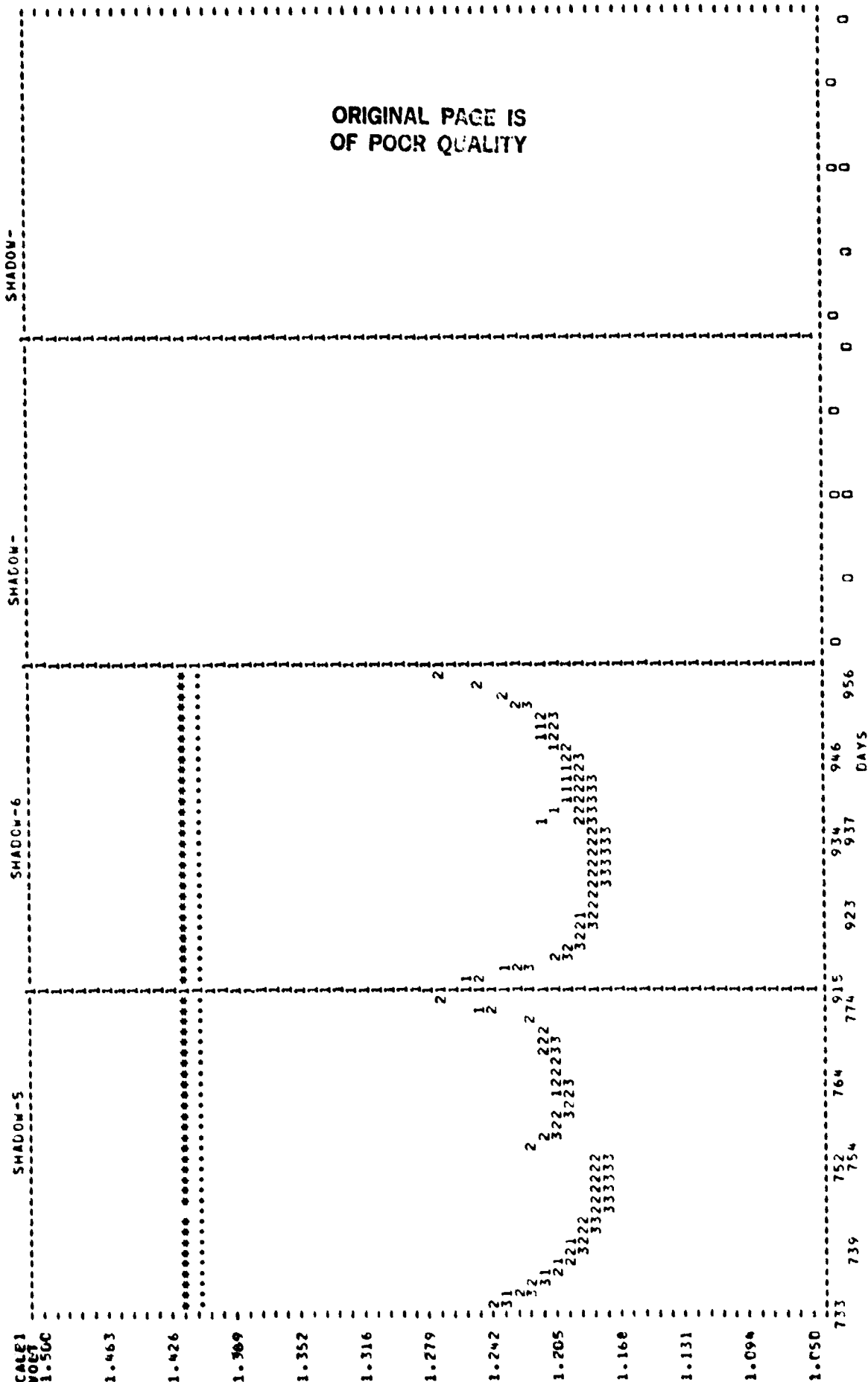
FIGURE 303

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE EAGLE-PICHER C
 PROJECT 90,98,94,96,82
 SERIAL

SYNCHRONOUS ORBIT SHADOW PLOT

MEV
 1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 4 HIGH EOC
 5 AVE EOC
 6 LOW EOC
 X
 Y

PACK = 229C



DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90 98 94 94 82
PAGE 8 OF 10

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 229C

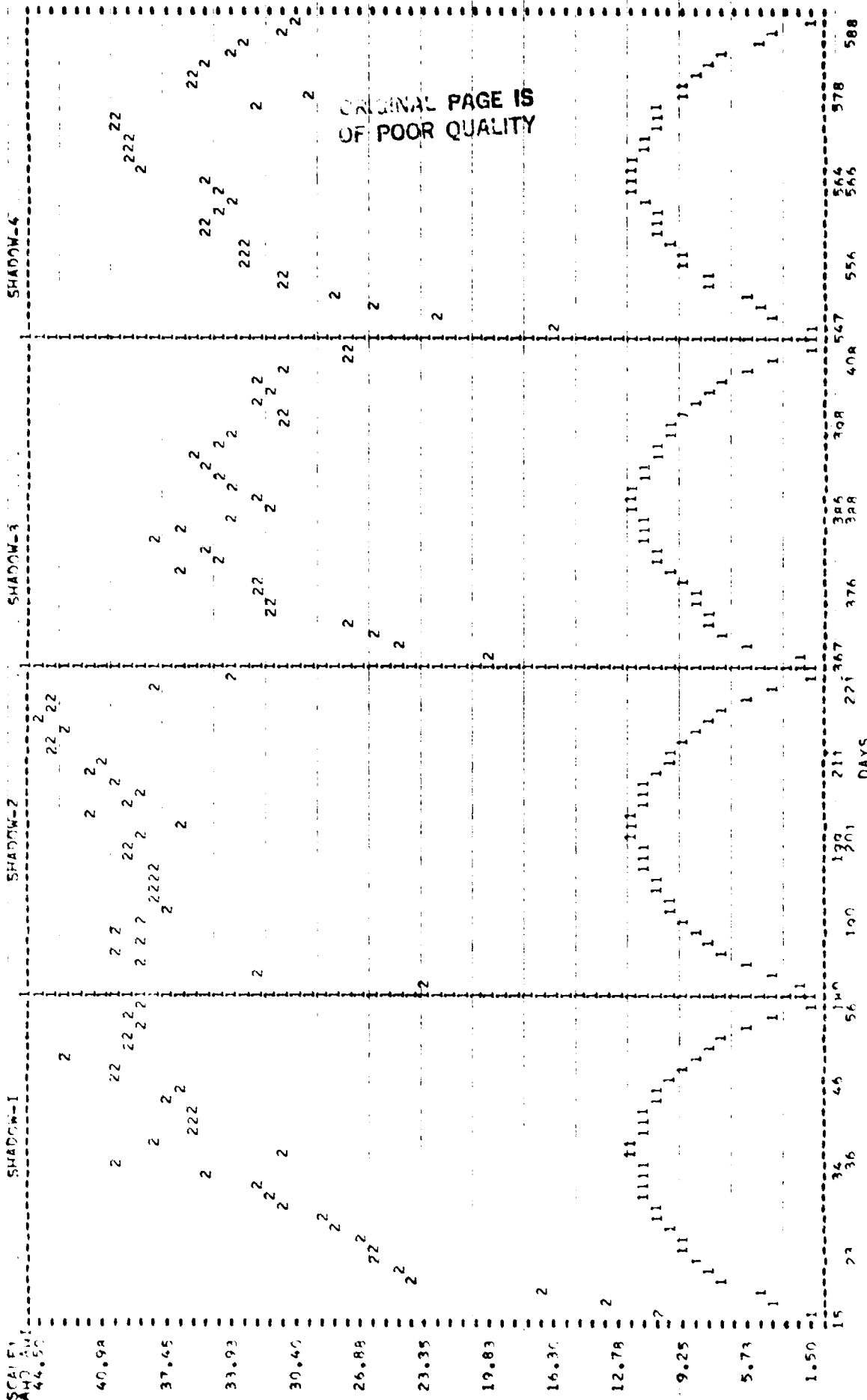


FIGURE 305

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90,98,99,96,82
EAGLE-PICHER C
PROJECT -

SYNCHRONOUS ORBIT SHADOW PLOT

РАСК = 229С

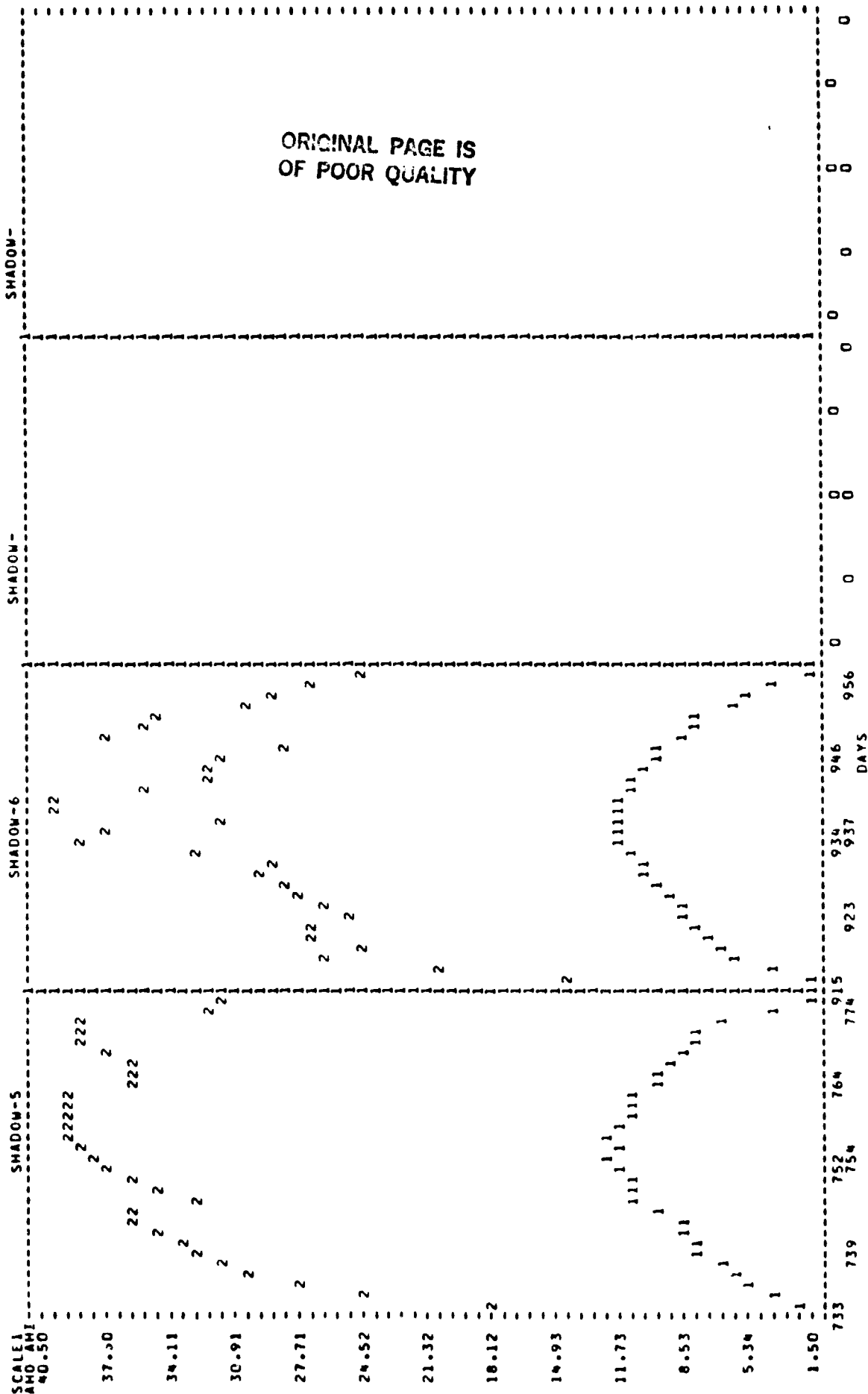


FIGURE 306

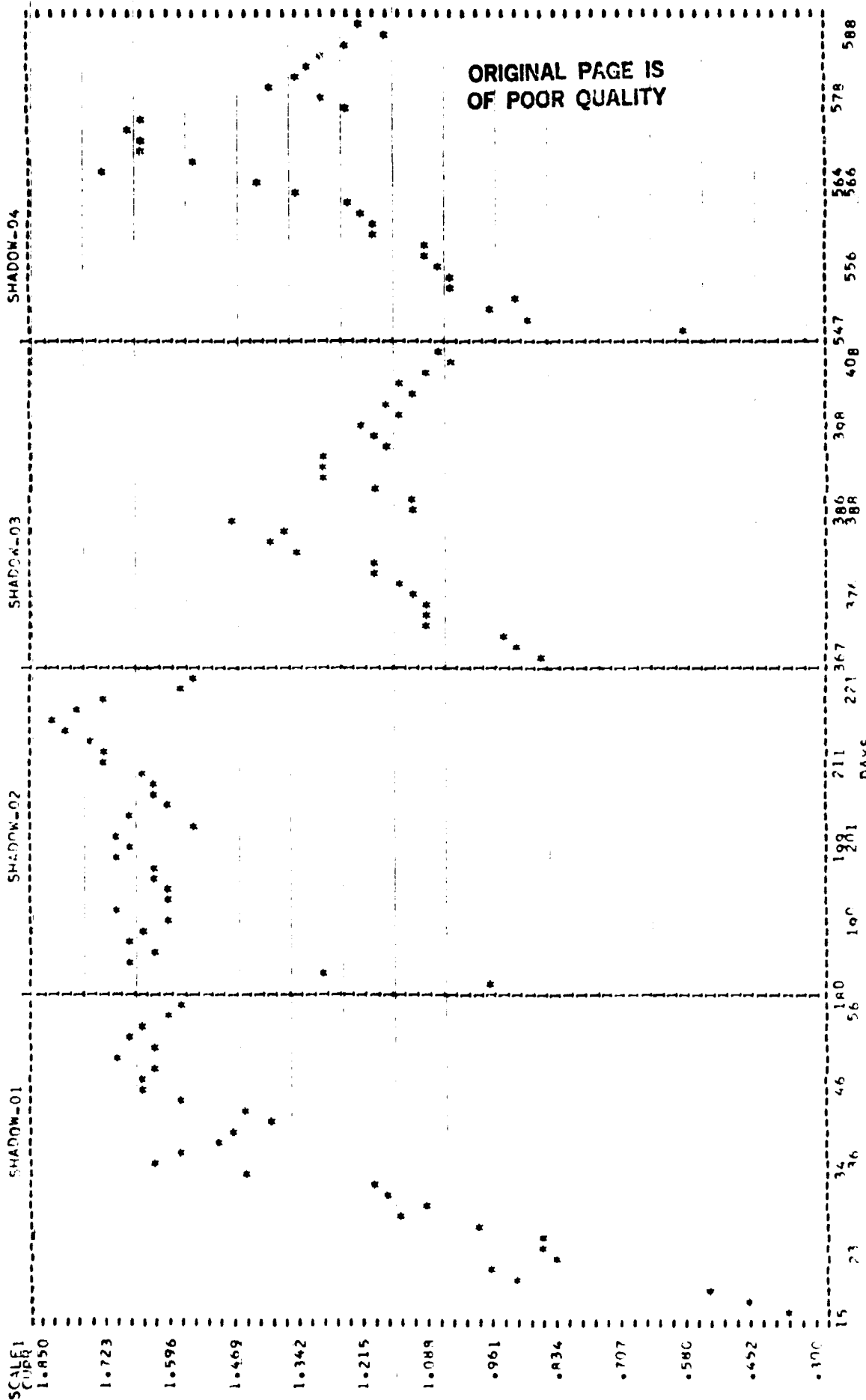
KEY
• FWD CHARGE CURRENT

SYNCHRONOUS OPBIT SHADOW PLAT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90,98,94,96,82

PROJECT : EAGLE-PICHER C

PACV = 220C



KEY
• END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90,98,99,96,82
PROJECT - EAGLE-PICHER C

PACH = 2290

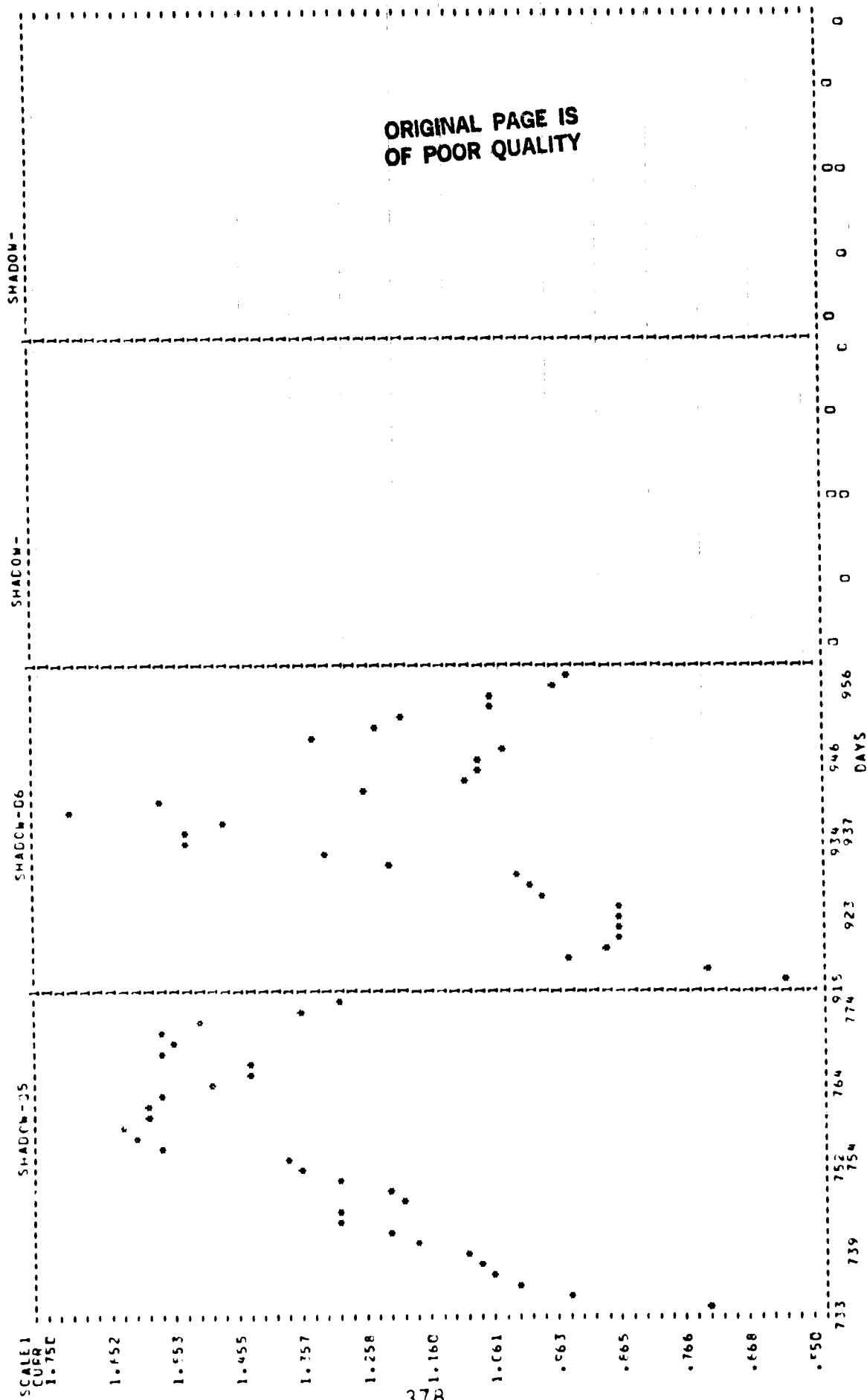


FIGURE 308

J. GE 20.0 ah (Standard Cell)

1. Pack 229A, 5-cells

a. Cell information: These cells met GSFC's requirement as a standard cell and are considered as a NASA Standard 20 AH Cell. The cells were manufactured for NASA, GSFC, under NASA contract number NAS 5-22461 according to the manufacturer's Manufacturing Control Document (MCD) 232A2222AA-84, whose design was intended to meet the requirements of GSFC's specification 74-15000 with amendments. The cells have teflonated negative electrodes and were identified by the manufacturers' catalog numbers 42B024AB06/07-G1/4/5 with one cell having an auxiliary electrode and another (cell 2) having a pressure transducer. Initial evaluation test results are contained in NAVWPNSUPPCEN Crane Report WQEC/C 79-144. Cells, of this type, are being evaluated on near-earth orbit test regimes.

b. Parameters:

| | | | |
|--------------------------|-------|----------------------|-----|
| Depth of Discharge (%) | 60 | Temperature (°C) | 20 |
| Charge Control | VL | Float Current (amps) | .33 |
| Charge Current (amps) | 2.00 | Auxiliary Electrode* | |
| Discharge Current (amps) | 10.00 | Resistance (ohms) | 300 |
| Voltage Limit (v/c) | 1.414 | | |

*--Cell 5

c. Capacity Checks: (Discharge each cell to .75 volts)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Precycling (Figure 309) | 1.021 | 1.146 | .844 | .179 | 1.119 | 22.98 |
| Shadow 1 (Figure 310) | | | | | 24.56 | |
| Shadow 2 (Figure 311) | | | | 24.13 | 22.51 | |
| Shadow 3 (Figure 312) | | | 22.57 | 21.87 | 21.36 | |
| Shadow 4 (Figure 313) | | 21.96 | 20.94 | 20.43 | 20.94 | |
| Shadow 5 (Figure 314) | 21.71 | 20.72 | 20.72 | 20.12 | 20.72 | |
| Shadow 6 (Figure 315) | | | | | 20.94 | |
| Shadow 7 (Figure 316) | | | | 20.22 | 20.83 | |
| Shadow 8 (Figure 317) | | | 21.69 | 20.94 | 21.69 | |
| Shadow 9 (Figure 318) | | 21.29 | 21.59 | 21.29 | 22.18 | |

d. Test results during the Shadow Periods: (Figure 319 to 327)

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.200 (shadow 1) to 1.154 volts (shadow 5) before it was capacity checked with the largest decrease (30 mv) being from shadow 1 to shadow 2. Its voltage during shadows 6 and 9 was 1.162 and 1.157 volts, respectively. The reconditioning effect on the voltages of those cells, which were capacity checked, during shadows 1 to 3, was not noticeable from

one mid-shadow to another until shadow 4 when the voltage of these cells averaged 8 mv higher than the other cells. This average was also 8 mv during the last shadow. The mid-shadow voltage of cell 5, which receives a capacity check each shadow, has averaged 1.164 volts the last 7 shadows. The decrease in voltages, the day following the capacity checks, is due to those cells being on open-circuit for 24 hours during these checks.

(2) Capacity/Reconditioning Effects: Cell 5, which is capacity checked each shadow, has degraded 9.7 percent in capacity from shadows 1 to 9; but its voltage degradation has resulted in a 30.7 percent decrease in capacity available to 1.10 volts and 13.6 percent to 1.00 volts. The other cells have shown approximately the same type of results. The average discharge voltage of those cells, which were capacity checked during the last shadow, increased 35 mv the day following this check. The reconditioning effect, due to the daily discharges, is obvious from the graphs as the values for the low end discharge voltages are higher during the second half of the shadows.

(3) End of Charge Voltages and Pressure: The mid-shadow cell voltages have remained balanced with a 3 mv difference between the high and low cells during shadow 1 and 4 mv during shadow 9. The mid-shadow pressure (cell 2) was 0 psia during the first six shadows, but was 8 psia the last shadow.

(4) Ampere-Hour Input: The mid-shadow input normally is 25 to 28 ah with a test temperature ranging from 19.6 to 20.5°C. If this temperature is 21°C, the pack temperature peaks at 24°C during charge and the input increases to approximately 30 ah, as it did during shadows 4, 5, and 8.

e. Performance during Sun Periods: Pack has completed 8 sun periods as it began test with a shadow period. The pressure has not exceeded 5 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period. Also, the current is listed when it was less than .33 amps due to the pack's voltage limit.

| Voltages** | 1 | | | 2 | | | 3 | | |
|------------|---------------|-------------|--|-------------|-------------|--|-------------|-------------|--|
| | Start | End | | Start | End | | Start | End | |
| High | 1.404 (1,3) | 1.412 (1,3) | | 1.408 (1) | 1.398 (3) | | 1.399 (1) | 1.400 (1,2) | |
| Average | 1.403 | 1.411 | | 1.405 | 1.396 | | 1.397 | 1.399 | |
| Low | 1.402 (2,4) | 1.410 (2) | | 1.402 (4) | 1.395 (5) | | 1.395 (4) | 1.397 (5) | |
| Voltages | 4 | | | 5 | | | 6 | | |
| | Start | End | | Start | End | | Start | End | |
| High | 1.400 (1) | 1.405 (1) | | 1.403 (1,5) | 1.407 (5) | | 1.405 (1,5) | 1.416 (1,3) | |
| Average | 1.398 | 1.403 | | 1.402 | 1.404 | | 1.404 | 1.415 | |
| Low | 1.397 (2,4,5) | 1.402 (2,3) | | 1.401 (2,4) | 1.402 (1,2) | | 1.403 (5) | 1.414 (5) | |
| Current | | | | | | | | .32 | |
| Voltages | 7 | | | 8 | | | | | |
| | Start | End | | Start | End | | | | |
| High | 1.404 (1,3) | 1.407 (1,3) | | 1.405 (1) | 1.416 (1) | | | | |
| Average | 1.403 | 1.406 | | 1.403 | 1.414 | | | | |
| Low | 1.401 (4) | 1.405 (4) | | 1.400 (4) | 1.413 (3,4) | | | | |
| Current | | | | | .27 | | | | |

**--() indicates which cell

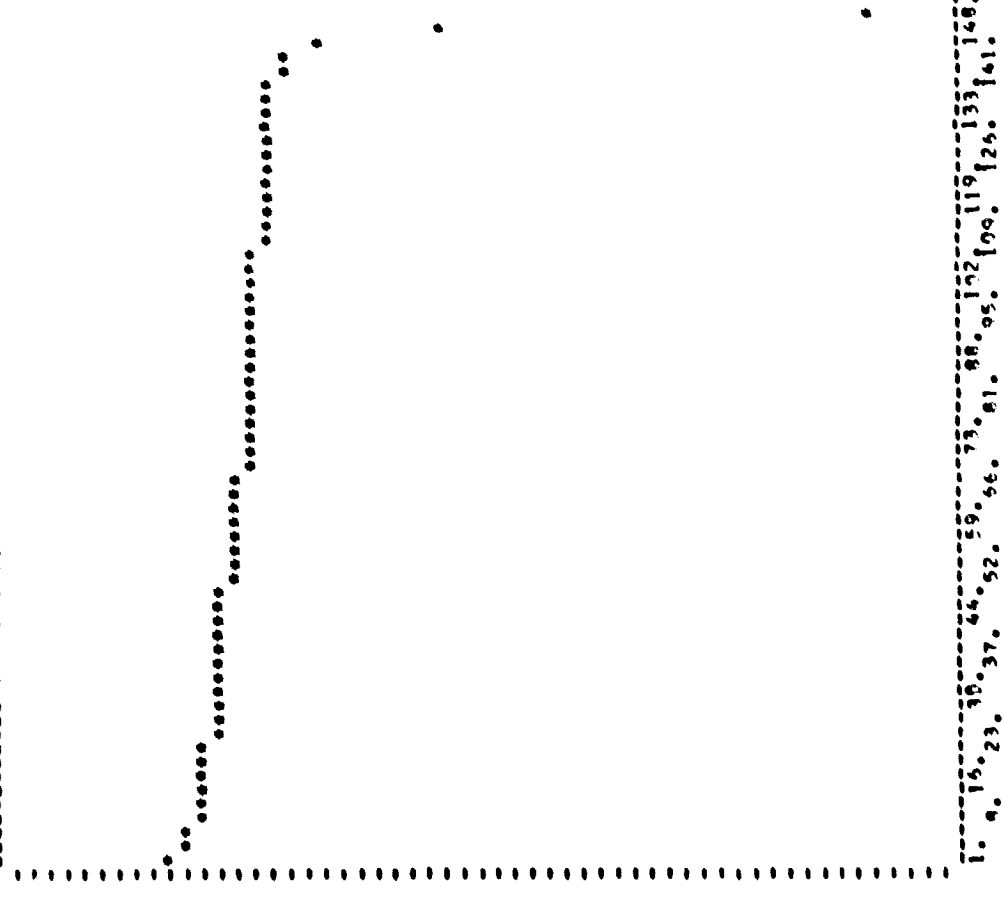
PACK NUMBER IS 229A
SHADOW PERIOD IS 31
CYCLE NUMBER IS 13
DATE IS 13.

ANDPDE WAP OUT

KEY HIGH CELL
LOW CELL
TYPE

1.58 2.69 5.08 7.42 9.82 12.19 14.52 16.91 19.22 22.14 24.54
3.98 6.26 8.64 11.01 13.37 15.73 18.11 20.93 23.35

C
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TIME IN MINUTES
CELLS INCLUDED

FIGURE 310

ORIGINAL PAGE IS
OF POOR QUALITY

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

BACK NUMBER IS 2294
 SHADOW PERIOD IS 02
 CYCLE NUMBER IS 0176
 DISCHARGE RATE IS 10.

WREC/C 81-120A

AMPERE HOUR OUT

00 2.43 4.46 7.29 9.73 12.16 14.59 17.03 19.47 21.90 24.13
 1. 21.65 2. 08 3. 51 4. 94 5. 38 6. 81 7. 23 8. 66 9. 109 10. 143

C 1.67
 A 1.57
 P 1.45
 A 1.33
 C 1.22
 I 1.11
 T 1.00
 Y .99
 C .98
 E .97
 L .96
 L .95
 V .94
 O .93
 L .92
 T .91
 A .90
 G .89
 E .88
 S .87
 C .86
 A .85
 L .84
 E .83

ORIGINAL PAGE IS
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1. 8. 15. 23. 30. 37. 44. 51. 59. 66. 73. 80. 88. 95. 102. 109. 116. 123. 130. 137. 144. 151. 158. 165. 172. 179. 186. 193. 200. 207. 214. 221. 228. 235. 242. 249. 256. 263. 270. 277. 284. 291. 298. 305. 312. 319. 326. 333. 340. 347. 354. 361. 368. 375. 382. 389. 396. 403. 410. 417. 424. 431. 438. 445. 452. 459. 466. 473. 480. 487. 494. 501. 508. 515. 522. 529. 536. 543. 550. 557. 564. 571. 578. 585. 592. 599. 606. 613. 620. 627. 634. 641. 648. 655. 662. 669. 676. 683. 690. 697. 704. 711. 718. 725. 732. 739. 746. 753. 760. 767. 774. 781. 788. 795. 802. 809. 816. 823. 830. 837. 844. 851. 858. 865. 872. 879. 886. 893. 900. 907. 914. 921. 928. 935. 942. 949. 956. 963. 970. 977. 984. 991. 998. 1005. 1012. 1019. 1026. 1033. 1040. 1047. 1054. 1061. 1068. 1075. 1082. 1089. 1096. 1103. 1110. 1117. 1124. 1131. 1138. 1145. 1152. 1159. 1166. 1173. 1180. 1187. 1194. 1201. 1208. 1215. 1222. 1229. 1236. 1243. 1250. 1257. 1264. 1271. 1278. 1285. 1292. 1299. 1306. 1313. 1320. 1327. 1334. 1341. 1348. 1355. 1362. 1369. 1376. 1383. 1390. 1397. 1404. 1411. 1418. 1425. 1432. 1439. 1446. 1453. 1460. 1467. 1474. 1481. 1488. 1495. 1502. 1509. 1516. 1523. 1530. 1537. 1544. 1551. 1558. 1565. 1572. 1579. 1586. 1593. 1600. 1607. 1614. 1621. 1628. 1635. 1642. 1649. 1656. 1663. 1670. 1677. 1684. 1691. 1698. 1705. 1712. 1719. 1726. 1733. 1740. 1747. 1754. 1761. 1768. 1775. 1782. 1789. 1796. 1803. 1810. 1817. 1824. 1831. 1838. 1845. 1852. 1859. 1866. 1873. 1880. 1887. 1894. 1901. 1908. 1915. 1922. 1929. 1936. 1943. 1950. 1957. 1964. 1971. 1978. 1985. 1992. 1999. 2006. 2013. 2020. 2027. 2034. 2041. 2048. 2055. 2062. 2069. 2076. 2083. 2090. 2097. 2104. 2111. 2118. 2125. 2132. 2139. 2146. 2153. 2160. 2167. 2174. 2181. 2188. 2195. 2202. 2209. 2216. 2223. 2230. 2237. 2244. 2251. 2258. 2265. 2272. 2279. 2286. 2293. 2300. 2307. 2314. 2321. 2328. 2335. 2342. 2349. 2356. 2363. 2370. 2377. 2384. 2391. 2398. 2405. 2412. 2419. 2426. 2433. 2440. 2447. 2454. 2461. 2468. 2475. 2482. 2489. 2496. 2503. 2510. 2517. 2524. 2531. 2538. 2545. 2552. 2559. 2566. 2573. 2580. 2587. 2594. 2601. 2608. 2615. 2622. 2629. 2636. 2643. 2650. 2657. 2664. 2671. 2678. 2685. 2692. 2699. 2706. 2713. 2720. 2727. 2734. 2741. 2748. 2755. 2762. 2769. 2776. 2783. 2790. 2797. 2804. 2811. 2818. 2825. 2832. 2839. 2846. 2853. 2860. 2867. 2874. 2881. 2888. 2895. 2902. 2909. 2916. 2923. 2930. 2937. 2944. 2951. 2958. 2965. 2972. 2979. 2986. 2993. 3000. 3007. 3014. 3021. 3028. 3035. 3042. 3049. 3056. 3063. 3070. 3077. 3084. 3091. 3098. 3105. 3112. 3119. 3126. 3133. 3140. 3147. 3154. 3161. 3168. 3175. 3182. 3189. 3196. 3203. 3210. 3217. 3224. 3231. 3238. 3245. 3252. 3259. 3266. 3273. 3280. 3287. 3294. 3301. 3308. 3315. 3322. 3329. 3336. 3343. 3350. 3357. 3364. 3371. 3378. 3385. 3392. 3399. 3406. 3413. 3420. 3427. 3434. 3441. 3448. 3455. 3462. 3469. 3476. 3483. 3490. 3497. 3504. 3511. 3518. 3525. 3532. 3539. 3546. 3553. 3560. 3567. 3574. 3581. 3588. 3595. 3602. 3609. 3616. 3623. 3630. 3637. 3644. 3651. 3658. 3665. 3672. 3679. 3686. 3693. 3700. 3707. 3714. 3721. 3728. 3735. 3742. 3749. 3756. 3763. 3770. 3777. 3784. 3791. 3798. 3805. 3812. 3819. 3826. 3833. 3840. 3847. 3854. 3861. 3868. 3875. 3882. 3889. 3896. 3903. 3910. 3917. 3924. 3931. 3938. 3945. 3952. 3959. 3966. 3973. 3980. 3987. 3994. 4001. 4008. 4015. 4022. 4029. 4036. 4043. 4050. 4057. 4064. 4071. 4078. 4085. 4092. 4099. 4106. 4113. 4120. 4127. 4134. 4141. 4148. 4155. 4162. 4169. 4176. 4183. 4190. 4197. 4204. 4211. 4218. 4225. 4232. 4239. 4246. 4253. 4260. 4267. 4274. 4281. 4288. 4295. 4302. 4309. 4316. 4323. 4330. 4337. 4344. 4351. 4358. 4365. 4372. 4379. 4386. 4393. 4400. 4407. 4414. 4421. 4428. 4435. 4442. 4449. 4456. 4463. 4470. 4477. 4484. 4491. 4498. 4505. 4512. 4519. 4526. 4533. 4540. 4547. 4554. 4561. 4568. 4575. 4582. 4589. 4596. 4603. 4610. 4617. 4624. 4631. 4638. 4645. 4652. 4659. 4666. 4673. 4680. 4687. 4694. 4701. 4708. 4715. 4722. 4729. 4736. 4743. 4750. 4757. 4764. 4771. 4778. 4785. 4792. 4799. 4806. 4813. 4820. 4827. 4834. 4841. 4848. 4855. 4862. 4869. 4876. 4883. 4890. 4897. 4904. 4911. 4918. 4925. 4932. 4939. 4946. 4953. 4960. 4967. 4974. 4981. 4988. 4995. 5002. 5009. 5016. 5023. 5030. 5037. 5044. 5051. 5058. 5065. 5072. 5079. 5086. 5093. 5100. 5107. 5114. 5121. 5128. 5135. 5142. 5149. 5156. 5163. 5170. 5177. 5184. 5191. 5198. 5205. 5212. 5219. 5226. 5233. 5240. 5247. 5254. 5261. 5268. 5275. 5282. 5289. 5296. 5303. 5310. 5317. 5324. 5331. 5338. 5345. 5352. 5359. 5366. 5373. 5380. 5387. 5394. 5401. 5408. 5415. 5422. 5429. 5436. 5443. 5450. 5457. 5464. 5471. 5478. 5485. 5492. 5499. 5506. 5513. 5520. 5527. 5534. 5541. 5548. 5555. 5562. 5569. 5576. 5583. 5590. 5597. 5604. 5611. 5618. 5625. 5632. 5639. 5646. 5653. 5660. 5667. 5674. 5681. 5688. 5695. 5702. 5709. 5716. 5723. 5730. 5737. 5744. 5751. 5758. 5765. 5772. 5779. 5786. 5793. 5800. 5807. 5814. 5821. 5828. 5835. 5842. 5849. 5856. 5863. 5870. 5877. 5884. 5891. 5898. 5905. 5912. 5919. 5926. 5933. 5940. 5947. 5954. 5961. 5968. 5975. 5982. 5989. 5996. 6003. 6010. 6017. 6024. 6031. 6038. 6045. 6052. 6059. 6066. 6073. 6080. 6087. 6094. 6101. 6108. 6115. 6122. 6129. 6136. 6143. 6150. 6157. 6164. 6171. 6178. 6185. 6192. 6199. 6206. 6213. 6220. 6227. 6234. 6241. 6248. 6255. 6262. 6269. 6276. 6283. 6290. 6297. 6304. 6311. 6318. 6325. 6332. 6339. 6346. 6353. 6360. 6367. 6374. 6381. 6388. 6395. 6402. 6409. 6416. 6423. 6430. 6437. 6444. 6451. 6458. 6465. 6472. 6479. 6486. 6493. 6500. 6507. 6514. 6521. 6528. 6535. 6542. 6549. 6556. 6563. 6570. 6577. 6584. 6591. 6598. 6605. 6612. 6619. 6626. 6633. 6640. 6647. 6654. 6661. 6668. 6675. 6682. 6689. 6696. 6703. 6710. 6717. 6724. 6731. 6738. 6745. 6752. 6759. 6766. 6773. 6780. 6787. 6794. 6801. 6808. 6815. 6822. 6829. 6836. 6843. 6850. 6857. 6864. 6871. 6878. 6885. 6892. 6899. 6906. 6913. 6920. 6927. 6934. 6941. 6948. 6955. 6962. 6969. 6976. 6983. 6990. 6997. 7004. 7011. 7018. 7025. 7032. 7039. 7046. 7053. 7060. 7067. 7074. 7081. 7088. 7095. 7102. 7109. 7116. 7123. 7130. 7137. 7144. 7151. 7158. 7165. 7172. 7179. 7186. 7193. 7200. 7207. 7214. 7221. 7228. 7235. 7242. 7249. 7256. 7263. 7270. 7277. 7284. 7291. 7298. 7305. 7312. 7319. 7326. 7333. 7340. 7347. 7354. 7361. 7368. 7375. 7382. 7389. 7396. 7403. 7410. 7417. 7424. 7431. 7438. 7445. 7452. 7459. 7466. 7473. 7480. 7487. 7494. 7501. 7508. 7515. 7522. 7529. 7536. 7543. 7550. 7557. 7564. 7571. 7578. 7585. 7592. 7599. 7606. 7613. 7620. 7627. 7634. 7641. 7648. 7655. 7662. 7669. 7676. 7683. 7690. 7697. 7704. 7711. 7718. 7725. 7732. 7739. 7746. 7753. 7760. 7767. 7774. 7781. 7788. 7795. 7802. 7809. 7816. 7823. 7830. 7837. 7844. 7851. 7858. 7865. 7872. 7879. 7886. 7893. 7900. 7907. 7914. 7921. 7928. 7935. 7942. 7949. 7956. 7963. 7970. 7977. 7984. 7991. 7998. 8005. 8012. 8019. 8026. 8033. 8040. 8047. 8054. 8061. 8068. 8075. 8082. 8089. 8096. 8103. 8110. 8117. 8124. 8131. 8138. 8145. 8152. 8159. 8166. 8173. 8180. 8187. 8194. 8201. 8208. 8215. 8222. 8229. 8236. 8243. 8250. 8257. 8264. 8271. 8278. 8285. 8292. 8299. 8306. 8313. 8320. 8327. 8334. 8341. 8348. 8355. 8362. 8369. 8376. 8383. 8390. 8397. 8404. 8411. 8418. 8425. 8432. 8439. 8446. 8453. 8460. 8467. 8474. 8481. 8488. 8495. 8502. 8509. 8516. 8523. 8530. 8537. 8544. 8551. 8558. 8565. 8572. 8579. 8586. 8593. 8600. 8607. 8614. 8621. 8628. 8635. 8642. 8649. 8656. 8663. 8670. 8677. 8684. 8691. 8698. 8705. 8712. 8719. 8726. 8733. 8740. 8747. 8754. 8761. 8768. 8775. 8782. 8789. 8796. 8803. 8810. 8817. 8824. 8831. 8838. 8845. 8852. 8859. 8866. 8873. 8880. 8887. 8894. 8901. 8908. 8915. 8922. 8929. 8936. 8943. 8950. 8957. 8964. 8971. 8978. 8985. 8992. 8999. 9006. 9013. 9020. 9027. 9034. 9041. 9048. 9055. 9062. 9069. 9076. 9083. 9090. 9097. 9104. 9111. 9118. 9125. 9132. 9139. 9146. 9153. 9160. 9167. 9174. 9181. 9188. 9195. 9202. 9209. 9216. 9223. 9230. 9237. 9244. 9251. 9258. 9265. 9272. 9279. 9286. 9293. 9300. 9307. 9314. 9321. 9328. 9335. 9342. 9349. 9356. 9363. 9370. 9377. 9384. 9391. 9398. 9405. 9412. 9419. 9426. 9433. 9440. 9447. 9454. 9461. 9468. 9475. 9482. 9489. 9496. 9503. 9510. 9517. 9524. 9531. 9538. 9545. 9552. 9559. 9566. 9573. 9580. 9587. 9594. 9601. 9608. 9615. 9622. 9629. 9636. 9643. 9650. 9657. 9664. 9671. 9678. 9685. 9692. 9699. 9706. 9713. 9720. 9727. 9734. 9741. 9748. 9755. 9762. 9769. 9776. 9783. 9790. 9797. 9804. 9811. 9818. 9825. 9832. 9839. 9846. 9853. 9860. 9867. 9874. 9881. 9888. 9895. 9902. 9909. 9916. 9923. 9930. 9937. 9944. 9951. 9958. 9965. 9972. 9979. 9986. 9993. 10000.

TIME IN MINUTES
 CELLS INCLUDED V-4 V-5

FIGURE 311

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER IS 229A
 SHADOW NUMBER IS 03
 CYCLE NUMBER IS 00310
 DISCHARGE RATE IS 10.
 40 2.82 5.24 7.66 10.07 12.49 14.91 17.33 20.15 22.17 22.57
 1.61 4.03 6.45 8.87 11.28 13.70 16.12 18.54 21.36

AMPERE HOUR CNT

C A P A C I T Y C E L L V O L T A G E S C A L E

1.57 1.54 1.51 1.48 1.45 1.42 1.37 1.34 1.31 1.28 1.25 1.22 1.19 1.16 1.13 1.10 1.07 1.04 1.01 0.99 0.96 0.93 0.90 0.87 0.84 0.81 0.78 0.75 0.72 0.69 0.66 0.63 0.60 0.57 0.54 0.51 0.48 0.45 0.42 0.39 0.36 0.33 0.30 0.27 0.24 0.21 0.18 0.15 0.12 0.09 0.06 0.03 0.00

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1. 16. 30. 45. 59. 73. 88. 102. 119. 138. 141.
 9. 16. 23. 37. 52. 66. 81. 95. 109. 126.

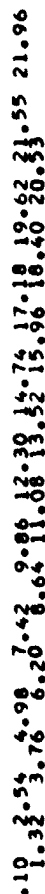
TIME IN MINUTES
 CELLS INCLUDED

V-3 V-4 V-5

FIGURE 312

PACK NUMBER IS 229A
SHADOW PERIOD IS 4 493
CYCLE NUMBER IS 15
DISCHARGE RATE IS 10.

AMPERE HOUR OUT



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| | | | | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| 1. | 16. | 31. | 45. | 59. | 73. | 88. | 102. | 117. | 136. | 138. |
| 9. | 23. | 37. | 52. | 66. | 81. | 95. | 109. | 129. | | |

| TIME IN MINUTES | | CELLS INCLUDED | | V-2 | V-3 | V-4 | V-5 |
|-----------------|-----|----------------|-----|-----|-----|-----|-----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 |
| 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 |
| 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 |
| 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 |
| 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 |
| 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 |
| 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 |
| 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 |
| 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 |
| 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 |
| 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 |
| 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 |
| 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 |
| 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 |
| 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 |
| 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 |
| 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 |
| 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 |
| 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 |
| 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 |
| 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 |
| 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 |
| 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 |
| 265 | 266 | 267 | 268 | 269 | 270 | 271 | 272 |
| 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 |
| 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 |
| 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 |
| 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 |
| 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 |
| 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 |
| 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 |
| 329 | 330 | 331 | 332 | 333 | 334 | 335 | 336 |
| 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 |
| 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 |
| 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 |
| 361 | 362 | 363 | 364 | 365 | 366 | 367 | 368 |
| 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 |
| 377 | 378 | 379 | 380 | 381 | 382 | 383 | 384 |
| 385 | 386 | 387 | 388 | 389 | 390 | 391 | 392 |
| 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 |
| 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 |
| 409 | 410 | 411 | 412 | 413 | 414 | 415 | 416 |
| 417 | 41 | | | | | | |

FIGURE 313

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PACK NUMBER IS 229A
SHADOW PERIOD IS 05
CYCLE NUMBER IS 673
DISCHARGE RATE IS 10.

AMPERE HOUR OUT

KEY
• HIGH CELL
• LOW CELL
• AVERAGE

1. 30 2. 50 3. 70 4. 90 5. 10 6. 30 7. 50 8. 70 9. 90 10. 10 11. 30 12. 50 13. 70 14. 90 15. 10 16. 30 17. 50 18. 70 19. 90 20. 10 21. 30 22. 50 23. 70 24. 90 25. 10 26. 30 27. 50 28. 70 29. 90 30. 10 31. 30 32. 50 33. 70 34. 90 35. 10 36. 30 37. 50 38. 70 39. 90 40. 10 41. 30 42. 50 43. 70 44. 90 45. 10 46. 30 47. 50 48. 70 49. 90 50. 10 51. 30 52. 50 53. 70 54. 90 55. 10 56. 30 57. 50 58. 70 59. 90 60. 10 61. 30 62. 50 63. 70 64. 90 65. 10 66. 30 67. 50 68. 70 69. 90 70. 10 71. 30 72. 50 73. 70 74. 90 75. 10 76. 30 77. 50 78. 70 79. 90 80. 10 81. 30 82. 50 83. 70 84. 90 85. 10 86. 30 87. 50 88. 70 89. 90 90. 10 91. 30 92. 50 93. 70 94. 90 95. 10 96. 30 97. 50 98. 70 99. 90 100. 10

C
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V
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C
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L
E

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 314

* TEST CELL
 * LOW CELL
 * AVERAGE

* SHADUO PERIOD 15 06
 * CYCLE NUMBER 15 856
 * DISCHARGE RATE 15 10.

AMPERE HOUR OUT

20 2.59 4.98 7.38 9.77 12.16 14.56 16.95 19.35 20.94
 1.39 3.79 6.18 8.57 10.97 13.36 15.75 18.15 20.54

C 1.60
 A 1.57
 P 1.54
 A 1.51
 C 1.48
 I 1.45
 T 1.42
 Y 1.40
 C 1.37
 I 1.34
 T 1.31
 Y 1.28
 C 1.25
 I 1.22
 T 1.19
 Y 1.16
 C 1.13
 I 1.10
 T 1.07
 Y 1.04
 C 1.01
 I .99
 T .96
 Y .93
 C .90
 I .87
 T .84
 Y .81
 C .78
 I .75
 T .72
 Y .69
 C .66
 I .63
 T .61
 Y .58
 C .55
 I .52
 T .49
 Y .46
 C .43
 I .40
 T .37
 Y .34
 C .31
 I .28
 T .25
 Y .22
 C .19
 I .17
 T .14
 Y .11
 C .08
 I .05
 T .02

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1. 8. 16. 29. 44. 58. 73. 87. 101. 116. 125.
 2. 8. 22. 37. 51. 65. 80. 94. 109. 123.

TIME IN MINUTES
 CELLS INCLUDED V-5

FIGURE 315

AMPERE HOUR OUT

PACK NUMBER IS 229A
SHADOW PERIOD IS 07
CYCLE NUMBER IS 1036
DISCHARGE RATE IS 10%

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126.

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126.

TIME IN MINUTES
CELLS INCLUDED V-4 V-5

FIGURE 316

ORIGINAL PAGE IS
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KEY
• HIGH CELL
• LOW CELL
• AVERAGE

C A P A C I T Y C E L L V O L T A G E S C A L E

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229A
 SHADOW PERIOD IS 09
 CYCLE NUMBER IS 1404
 DISCHARGE RATE IS 10.

WQEC/C 81-120A

AMPERE HOUR OUT

20 2.61 5.00 7.39 9.77 12.15 14.53 16.92 19.30 21.59 22.18
 1.40 3.80 6.19 8.58 10.96 13.34 15.73 18.11 20.49

C 1.59
 A 1.54
 P 1.51
 A 1.48
 C 1.45
 I 1.42
 T 1.39
 Y 1.36
 C 1.33
 E 1.30
 L 1.27
 L 1.24
 V 1.21
 O 1.18
 L 1.15
 T 1.12
 A 1.09
 G 1.06
 E 1.03
 S 1.00
 C 0.97
 A 0.94
 L 0.91
 E 0.88

1. 8. 15. 22. 29. 37. 44. 51. 58. 65. 73. 80. 87. 94. 101. 116. 133. 137.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 318

ORIGINAL PAGE IS
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DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 GENERAL ELECTRIC CELLS
 PROJECT 1 STANDARD CELL
 SERIAL 010.035.022.039.060

SYNCHRONOUS ORBIT SHADOW PLOT

1 HIGH DISCHARGE VOLTAGE
 2 AVE DISCHARGE VOLTAGE
 3 LOW DISCHARGE VOLTAGE
 4 HIGH EOC
 5 AVE EOC
 6 LOW EOC
 X Y

PACK = 229A

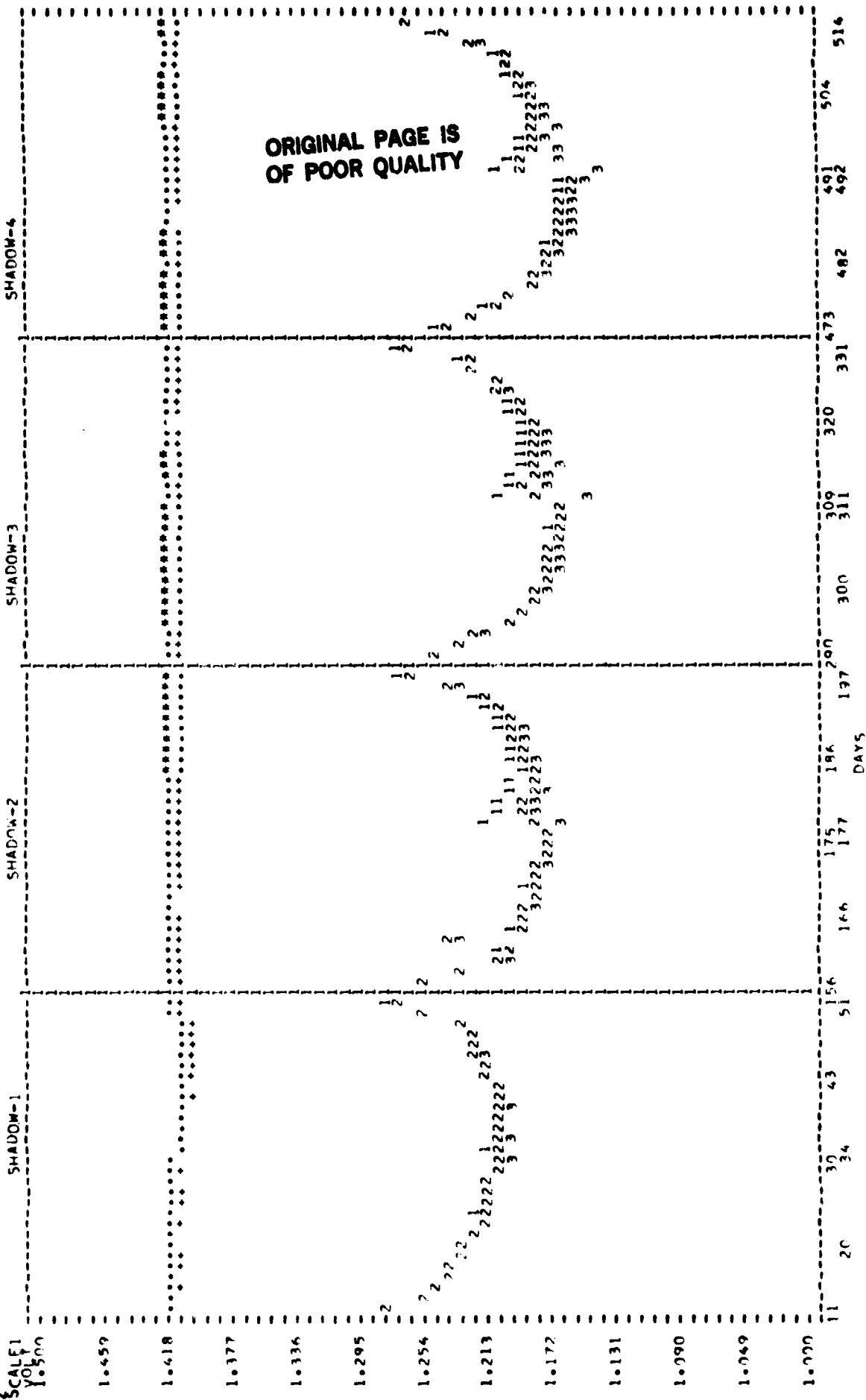


FIGURE 319

227 HIGH FIVE FOX
228 DISCHARGE VON TAGE
229 DISCHARGE VON TAGE
230 DISCHARGE VON TAGE

SHADOCS

06-1
17-05

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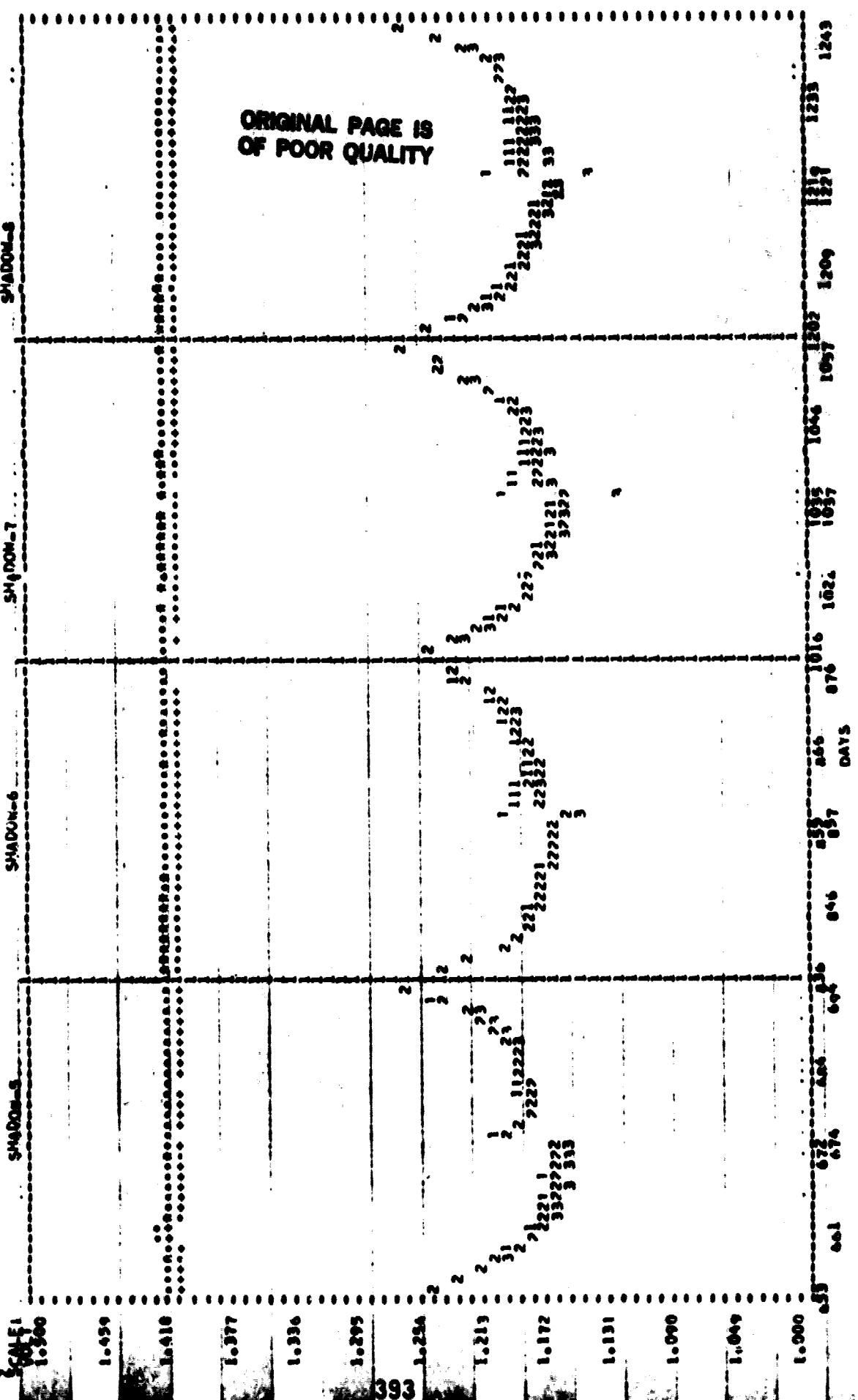


FIGURE 320

KEY
 1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 4 HIGH FUL DISCHARGE VOLTAGE
 5 AVE FUL DISCHARGE VOLTAGE
 6 LOW FUL DISCHARGE VOLTAGE

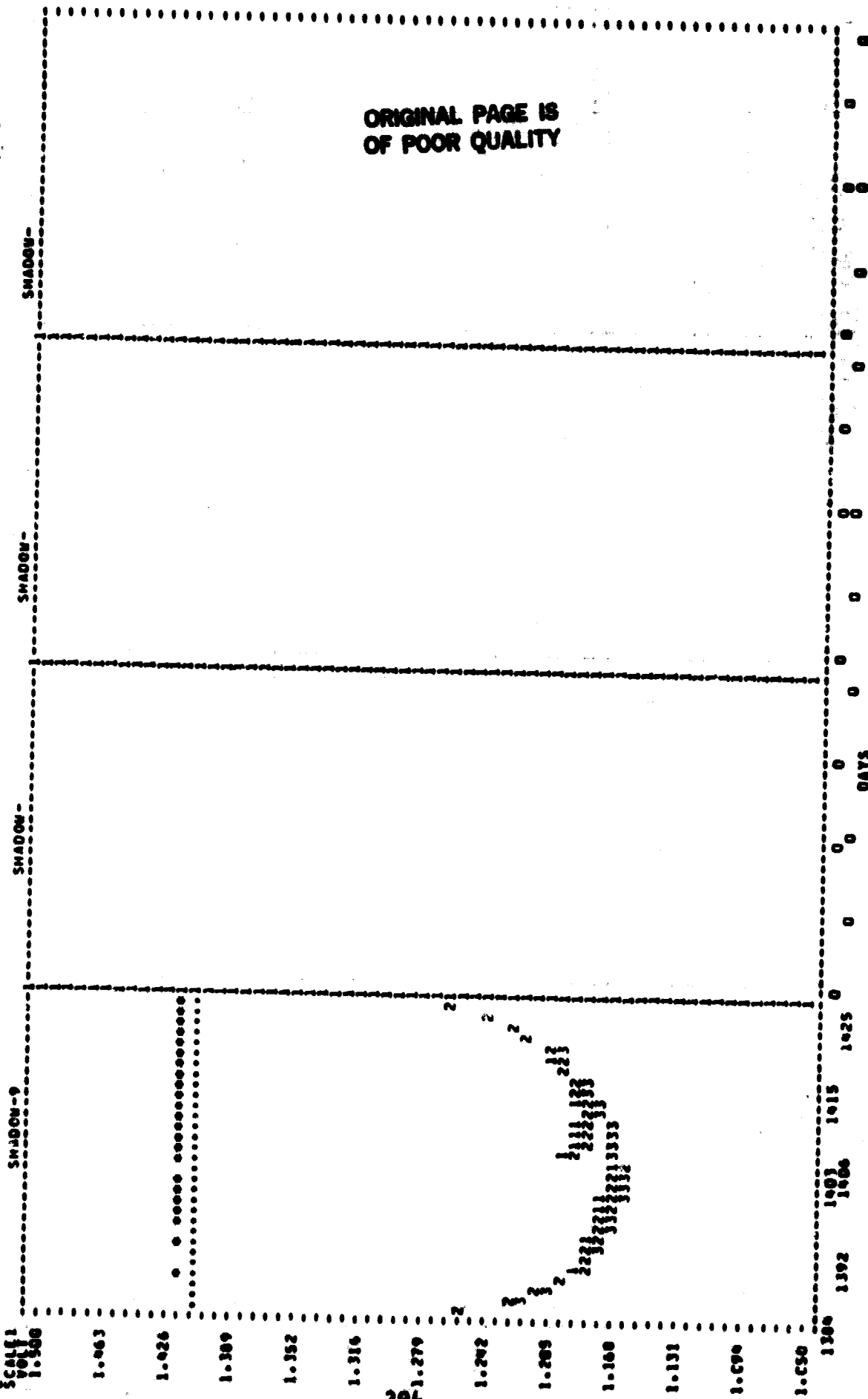
SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A

TEMPERATURE 10
 CURRENT RATE 10
 GENERAL ELECTRIC CELLS

PROJECT STANDARD CELL
 SERIAL 010,035,022,039,040

PACK = 220A



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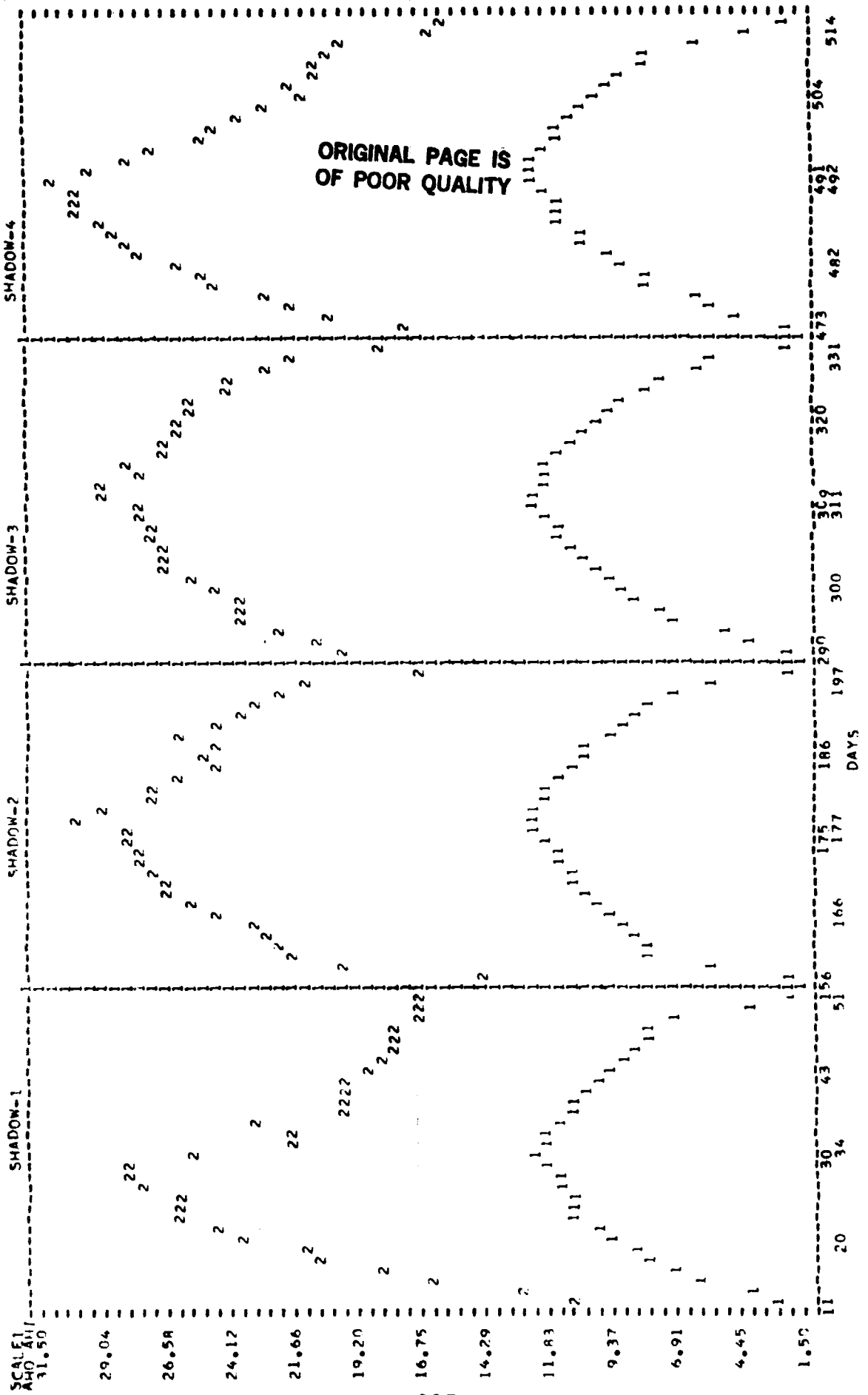
FIGURE 321

KEY
1 AHO
2 ANI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60 WQEC/C 81-120A
TEMPERATURE 20
TEMPERATURE 20
SERIAL 016.035, 022.039, 060
GENERAL ELECTRIC CELL
PROJECT V STANDARD CELL

PACK = 229A



CPY
1 ANY-TOTAL
3

SYNCHRONOUS ORBIT SPALCON PLOT

PERM DISCHARGE 60
TEMPERATURE 20
WDEG/C 21-120A
SERIAL RATE 002.039.060
SERIAL 0102033
GENERAL ELECTRIC CELLS
PROJECT : STANDARD CELL

P-CR = 2294

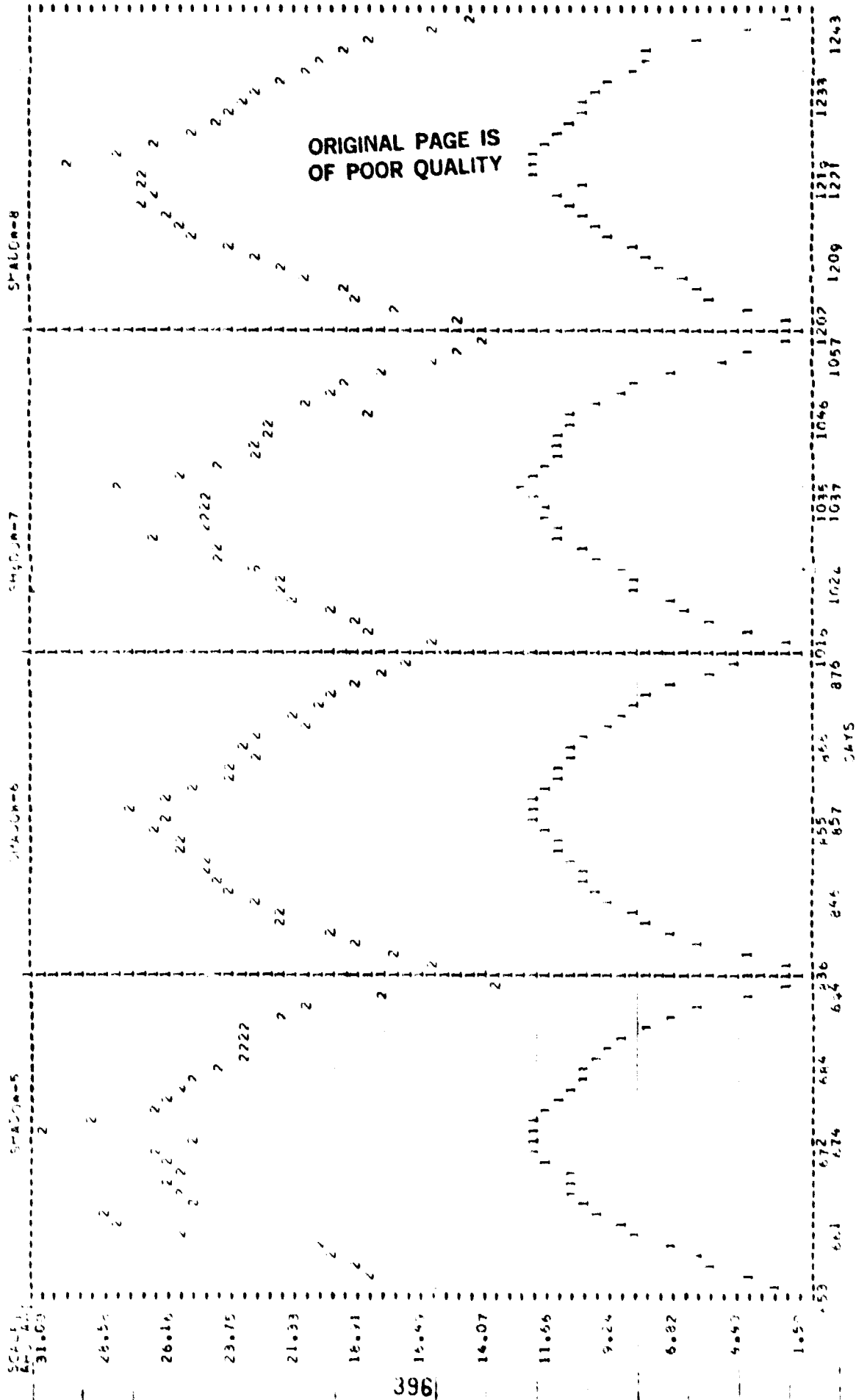


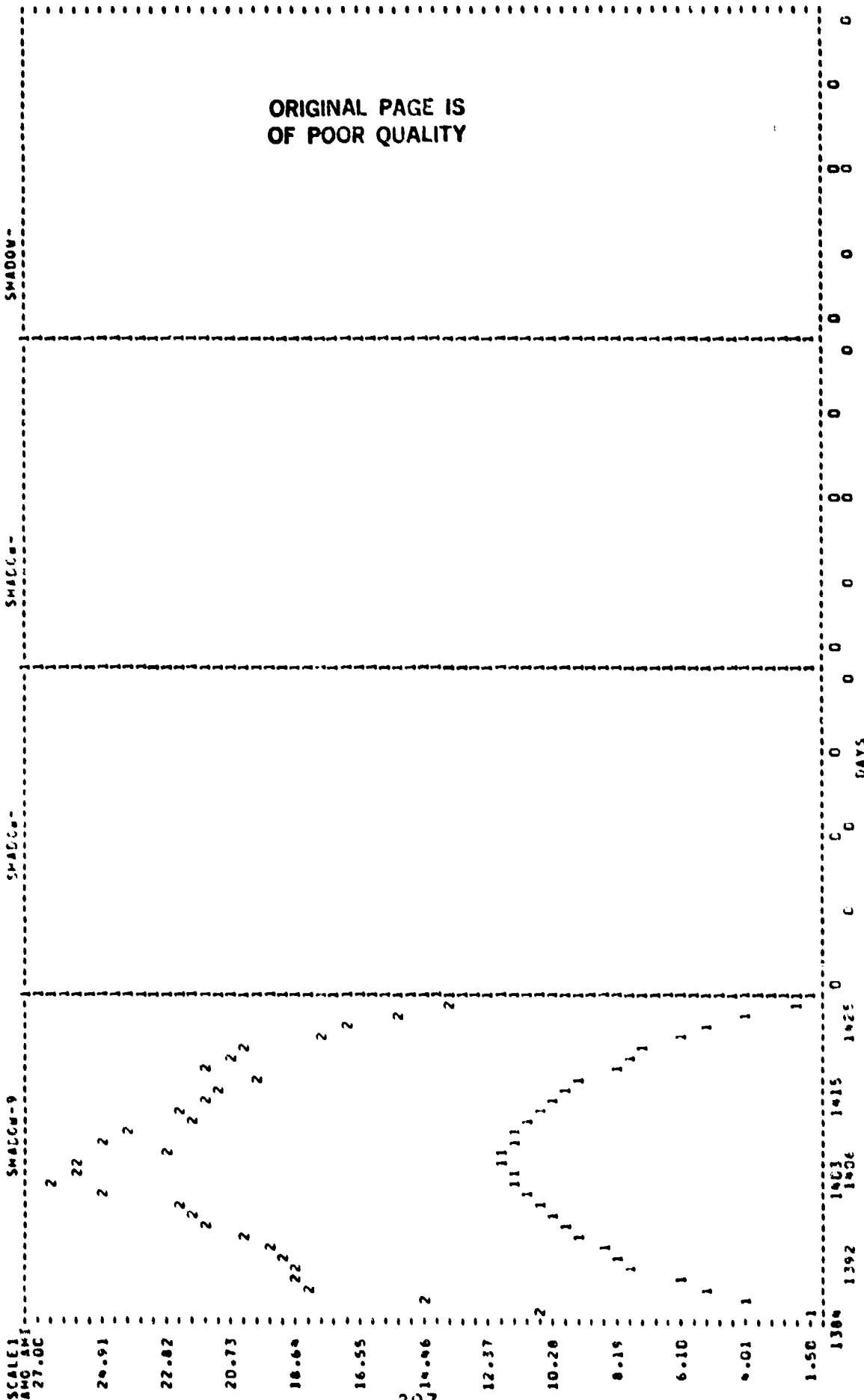
FIGURE 323

DEPTN DISCHARGE 60
 TEMPERATURE 20
 AMPIRE RATE 20
 SERIAL 010.037.022.039.060
 GENERAL ELECTRIC CELL
 PROJECT - STANDARD CELL

SYNCHRONOUS CREDIT SHADOW PLOT

PCOM = 2257

KEY
 1 AMO
 2 AMI-TOTAL
 3



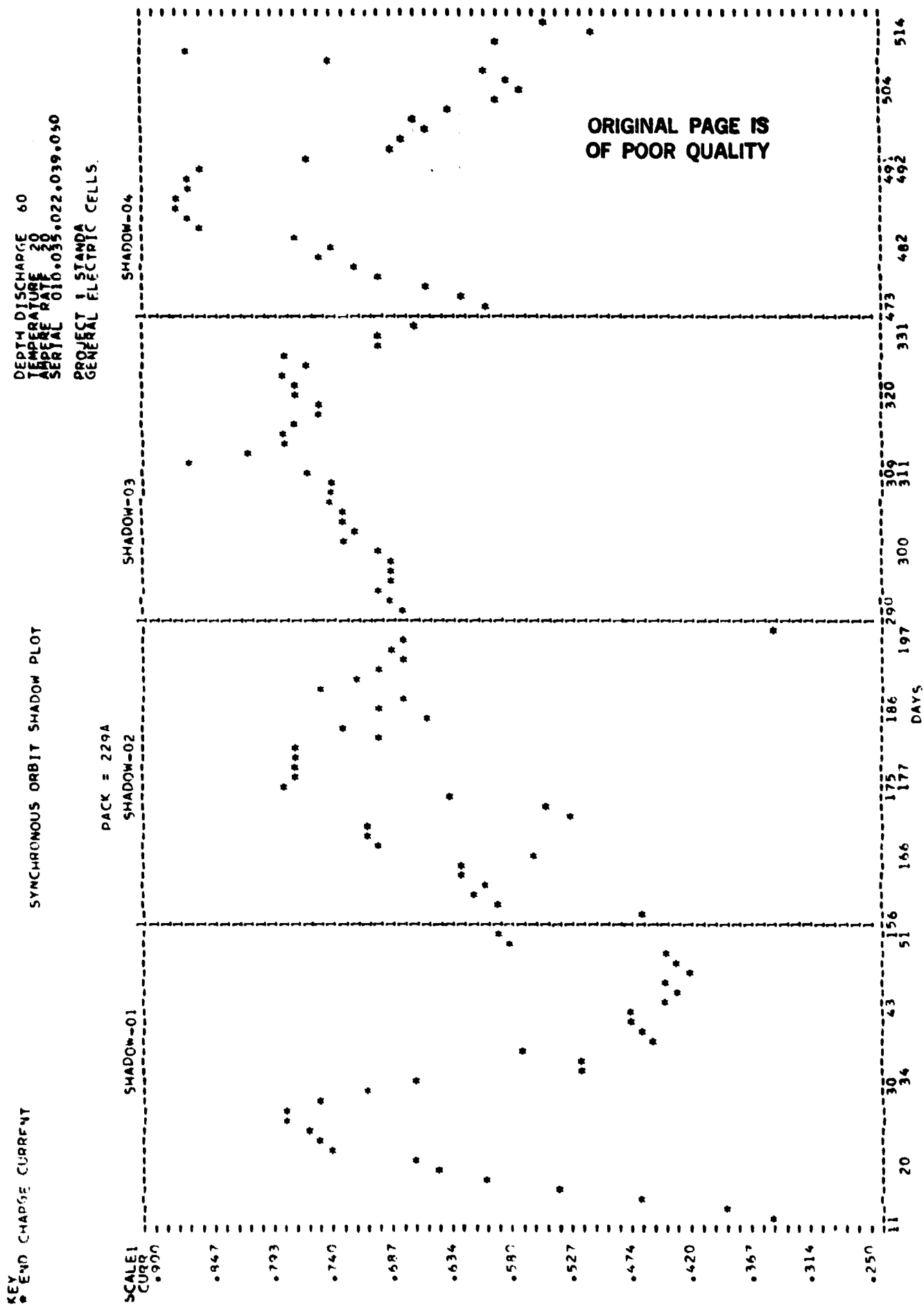


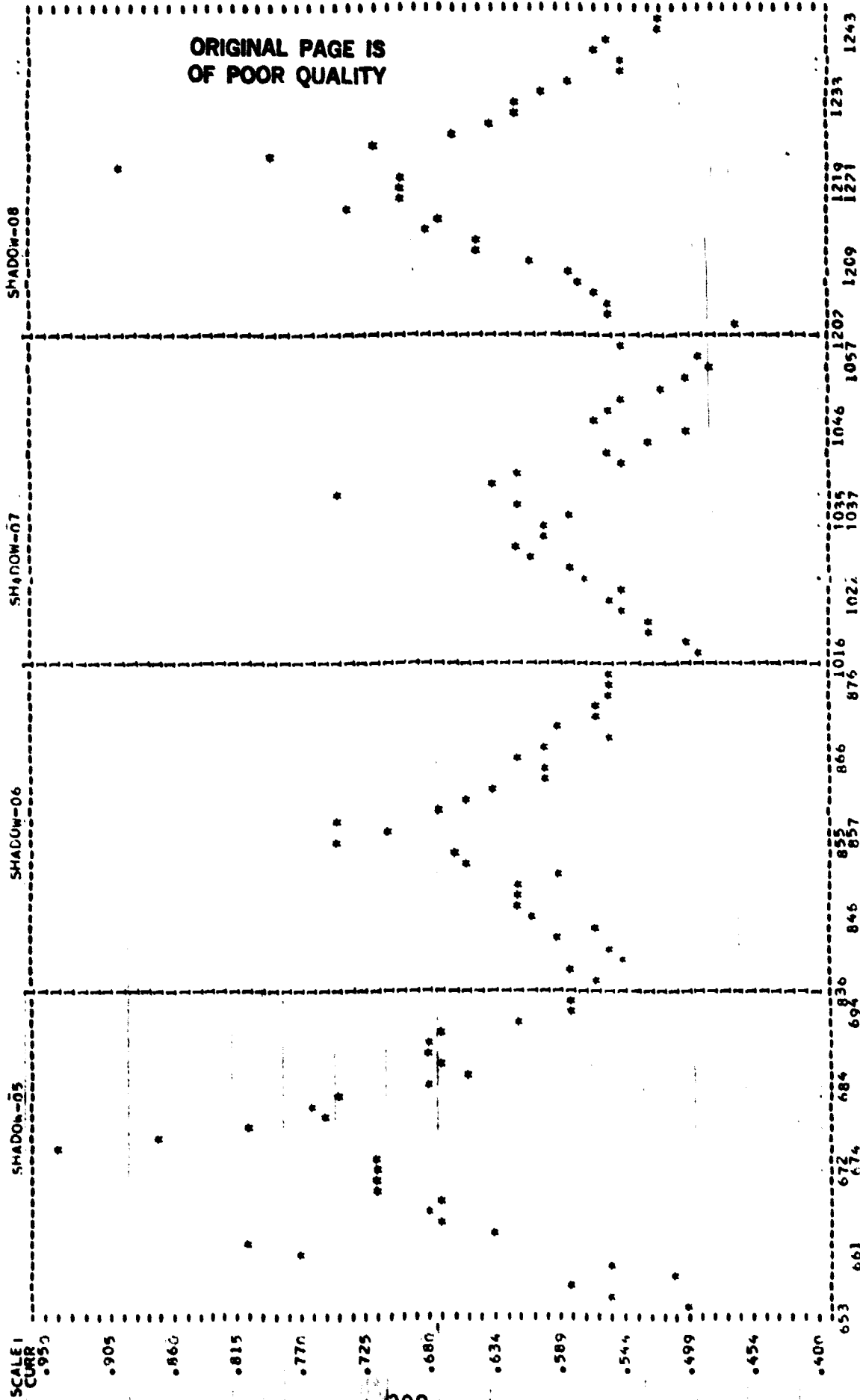
FIGURE 325

KEY
P E ID CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 010,035,022,039,060
PROJECT : STANDARD
GENERAL ELECTRIC CELLS

PACK = 229A



KEY
• END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 010,035,022,039,060
PROJECT STANDARD CELL
GENERAL ELECTRIC CELLS

PACK - 229A

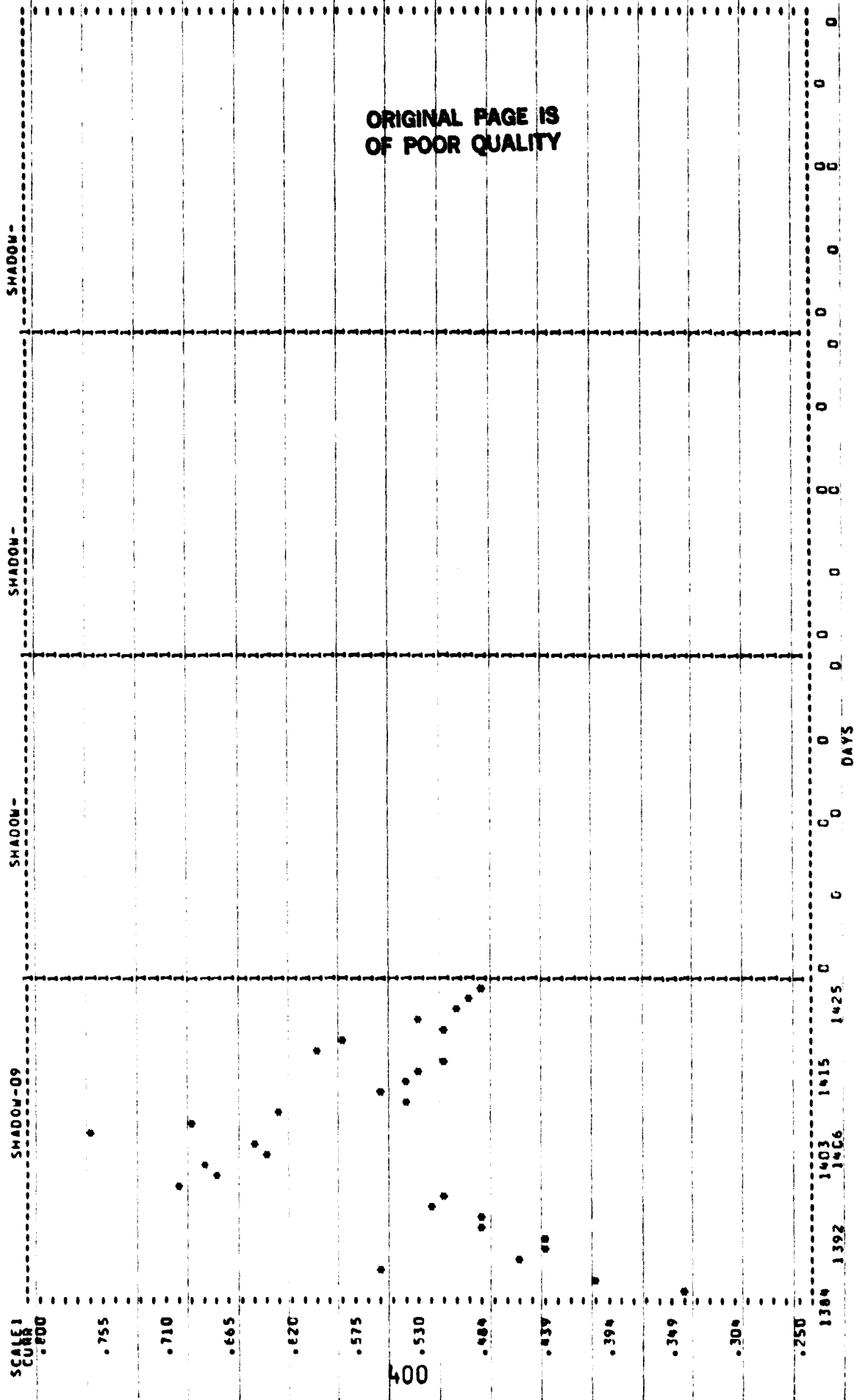


FIGURE 327

K. SAFT 20.0 ah

1. Pack 229B, 5-cells

a. Cell information: These cells did not meet GSFC's requirements as a standard cell. The cells were manufactured for NASA, GSFC, under NASA contract number NAS 5-22461 according to the manufacturer's Manufacturing Control Document (MCD) MCD NAS-0300, whose design was intended to meet the requirements of GSFC's specification 74-15000 with amendments. The cells were identified by the manufacturer's model numbers V020HS/V020HSAD and part numbers 805129/805136 with one cell having an auxiliary electrode. Cell 2 was fitted with a pressure transducer prior to testing. Initial evaluation test results are contained in NAVWPNSUPPCEN Crane Report WQEC/C 79-144. Cells, of this type, were evaluated on near-earth orbit test regimes.

b. Parameters:

| | | | |
|--------------------------|-------|----------------------|-----|
| Depth of Discharge (%) | 60 | Temperature (°C) | 20 |
| Charge Control | VL | Float Current (amps) | .33 |
| Charge Current (amps) | 2.00 | Auxiliary Electrode* | |
| Discharge Current (amps) | 10.00 | Resistance (ohms) | 47 |
| Voltage Limit (v/c) | 1.414 | | |

*--Cell 5

c. Capacity Checks: (Discharge each cell to .75 volts)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Precycling (Figure 328) | .145 | .851 | 1.126 | 1.118 | .947 | 22.86 |
| Shadow 1 (Figure 329) | | | | | 23.62 | |
| Shadow 2 (Figure 330) | | | | 23.74 | 23.33 | |
| Shadow 3 (Figure 331) | | | 23.73 | 23.53 | 23.23 | |
| Shadow 4 (Figure 332) | | 22.22 | 22.31 | 22.41 | 21.61 | |
| Shadow 5 (Figure 333) | 23.22 | 22.16 | 22.56 | 23.05 | 22.16 | |
| Shadow 6 (Figure 334) | | | | | 22.32 | |

d. Test results during the Shadow Periods: (Figure 335 to 340)

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.169 (shadow 1) to 1.141 volts (shadow 5) before it was capacity checked, with the largest decrease (12 mv) being from shadow 1 to 2. The reconditioning effect on the voltages of those cells, which were capacity checked during shadows 1 to 3, was not noticeable from one mid-shadow to another until shadow 4 when the voltage of these cells averaged 9 mv higher than the other cells. This average was 11 mv during shadow 5. The mid-shadow voltage of cell 5, which receives a capacity check each shadow, has average 1.151 volts the last 4 shadows. The decrease in voltages, the day following the capacity checks, is due to those cells being on open-circuit for 24 hours during these checks.

(2) Capacity/Reconditioning Effects: Cell 5, which is capacity checked each shadow, has degraded 5.5 percent in capacity from shadows 1 to 6; but its voltage degradation has resulted in a 26.9 percent decrease in capacity available to 1.10 volts and 12.4 percent to 1.00 volts. The discharge voltages of those cells, which are capacity checked, have increased from 27 to 48 mv the day following these checks with the less frequent checked cells having the greatest increase. The reconditioning effect, due to the daily discharges, is obvious from the graphs as the values for the low end discharge voltages are higher during the second half of the shadows.

(3) End of Charge Voltages and Pressures: The mid-shadow cell voltages have remained balanced with a 2 to 3 mv difference between the high and low cells. The cells were unbalanced at the start of shadows 2, 4, 5, and 6 for about 6 days. This unbalance corresponds to the unbalance in the voltages at the end of the sun periods prior to these shadows. The mid-shadow pressure (cell 2) was 36 psia during shadow 1, decreased to 11 psia the next shadow, and was 0 psia during the last shadow.

(4) Ampere-Hour Input: The mid-shadow input increased from 20.6 (shadow 1) to 30.8 ah (shadow 5) and was 28.8 ah the last shadow. During shadow 5, the packs temperature was 24°C at EOC although it had peaked at 25.6°C during this charge with the test temperature being 20.5°C. During shadow 6 the test temperature was 19.2°C and the pack's EOC temperature was 23.2°C and it had peaked at 24.5°C.

e. Performance during Sun Periods: Pack has completed 5 sun periods as it began test with a shadow period. The pressure has not exceeded 0 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period. Also, the current is listed when it was less than .33 amps due to the pack's voltage limit.

| Voltages** | 1 | | | 2 | | | 3 | | |
|------------|-------------|-----------|-----------|-----------------|-----------|-----------|-------|-----------|-------|
| | Start | End | Start | End | Start | End | Start | End | Start |
| High | 1.398 (1,2) | 1.417 (2) | 1.404 (2) | 1.405 (2,3,4,5) | 1.410 (2) | 1.419 (1) | 1.414 | 1.411 (3) | .32 |
| Average | 1.396 | 1.413 | 1.402 | 1.404 | 1.408 | 1.414 | 1.407 | 1.411 (3) | |
| Low | 1.395 (4,5) | 1.405 (1) | 1.400 (1) | 1.403 (1) | (1,3,4,5) | | | | |
| Current | | | | | | | | | |

| Voltages | 4 | | | 5 | | |
|----------|-----------|-----------|-----------|-----------|-------|-----------|
| | Start | End | Start | End | Start | End |
| High | 1.403 (1) | 1.408 (1) | 1.403 (1) | 1.411 (2) | 1.401 | 1.390 (4) |
| Average | 1.401 | 1.401 | 1.402 | 1.401 | | |
| Low | 1.400 (3) | 1.393 (4) | 1.400 (5) | | | |

**--() indicates which cell

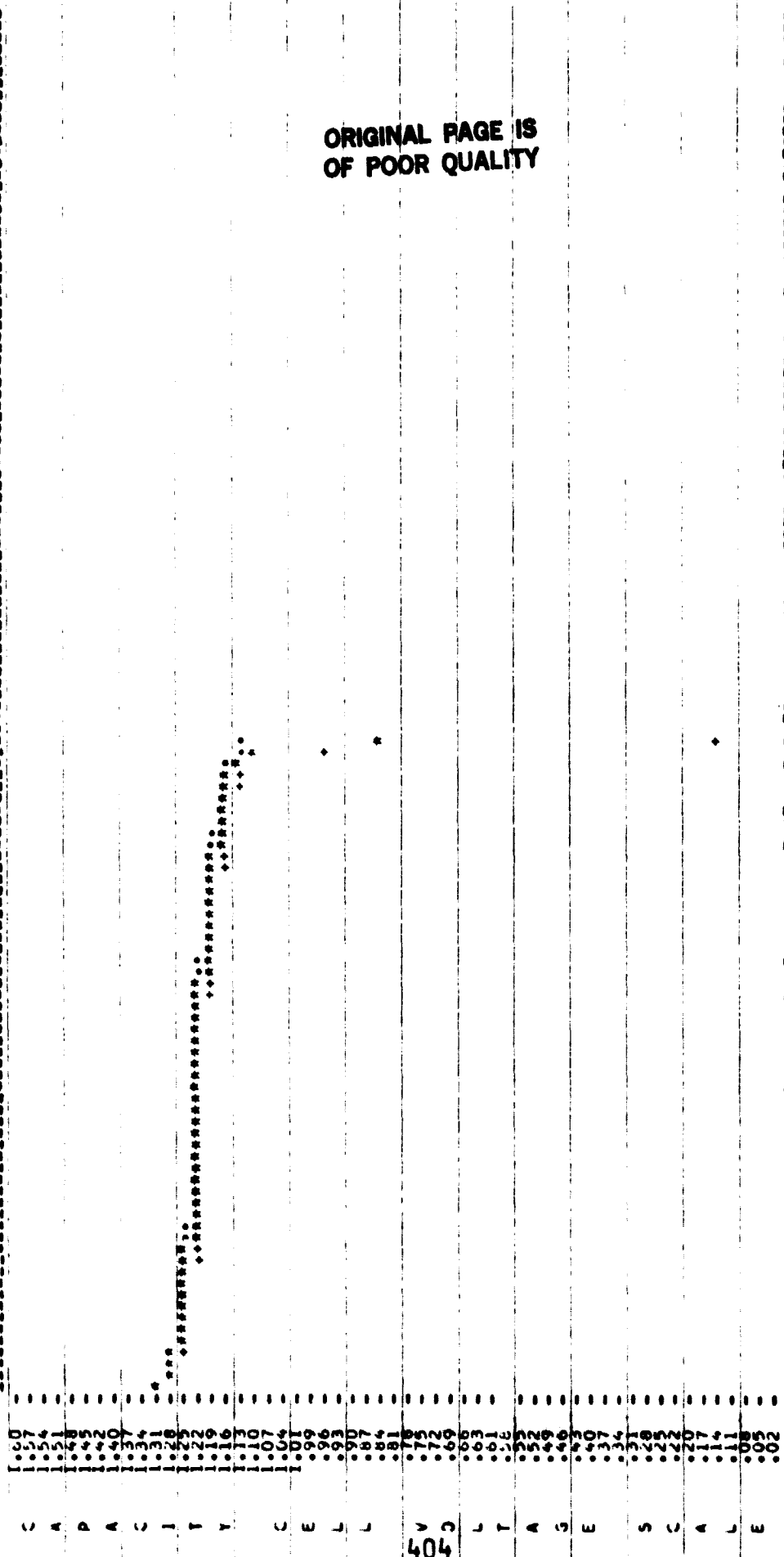
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KEY
• HIGH CELL
• LOW CELL
• AVERAGE

PACK NUMBER IS 2298
PRE-CYCLING
CYCLE NUMBER IS 10
DISCHARGE RATE IS 10%

30 2.73 5.13 7.55 9.97 12.39 14.81 17.22 19.64 22.06 22.86
1.51 3.92 6.34 8.76 11.18 13.60 16.01 18.43 20.85

AMPERE HOUR OUT



TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 328

PACK NUMBER IS 229B
SHADOW PERIOD IS 1
CYCLE NUMBER IS 35
DISCHARGE RATE IS 10.
20 3.67 5.54 7.60 10.06 12.53 15.00 17.46 19.93 22.39
1.43 3.90 6.36 8.83 11.30 13.76 16.23 18.69 21.16 23.62

AMPERE HOUR OUT

ORIGINAL PAGE IS
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KEY
: HIGH CELL
: LOW CELL
: AVERAGE

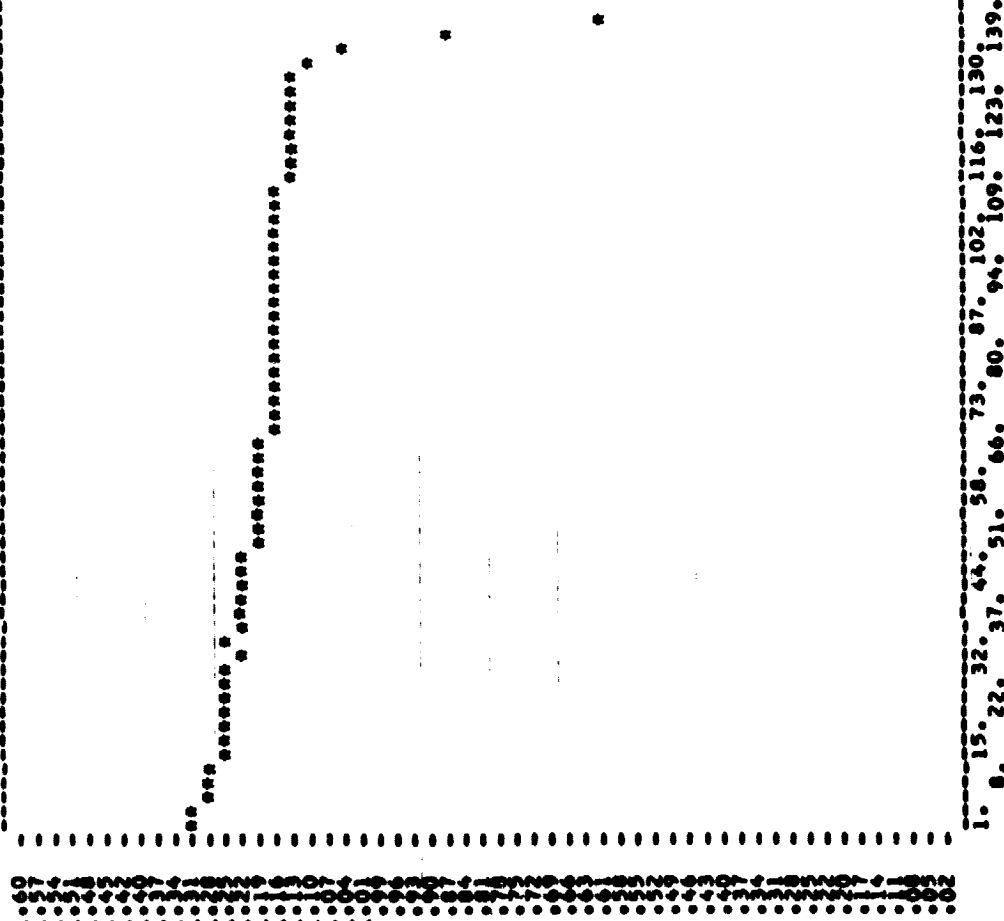


FIGURE 329

PACK NUMBER IS 229B
 SHADOW PERIOD IS 02
 CYCLE NUMBER IS 200
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

30 2.73 3.15 7.57 8.99 12.43 14.85 17.27 19.70 22.13 23.73
 1.51 3.93 6.36 8.78 11.21 13.63 16.06 18.48 20.91 23.33

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

07 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000

C A P A C I T Y C E L L V O L T A G E S C A L E

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1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 89. 95. 102. 117. 131. 145.
 124. 138.

CELLS INCLUDED
 TIME IN MINUTES
 V-4 V-5

FIGURE 330

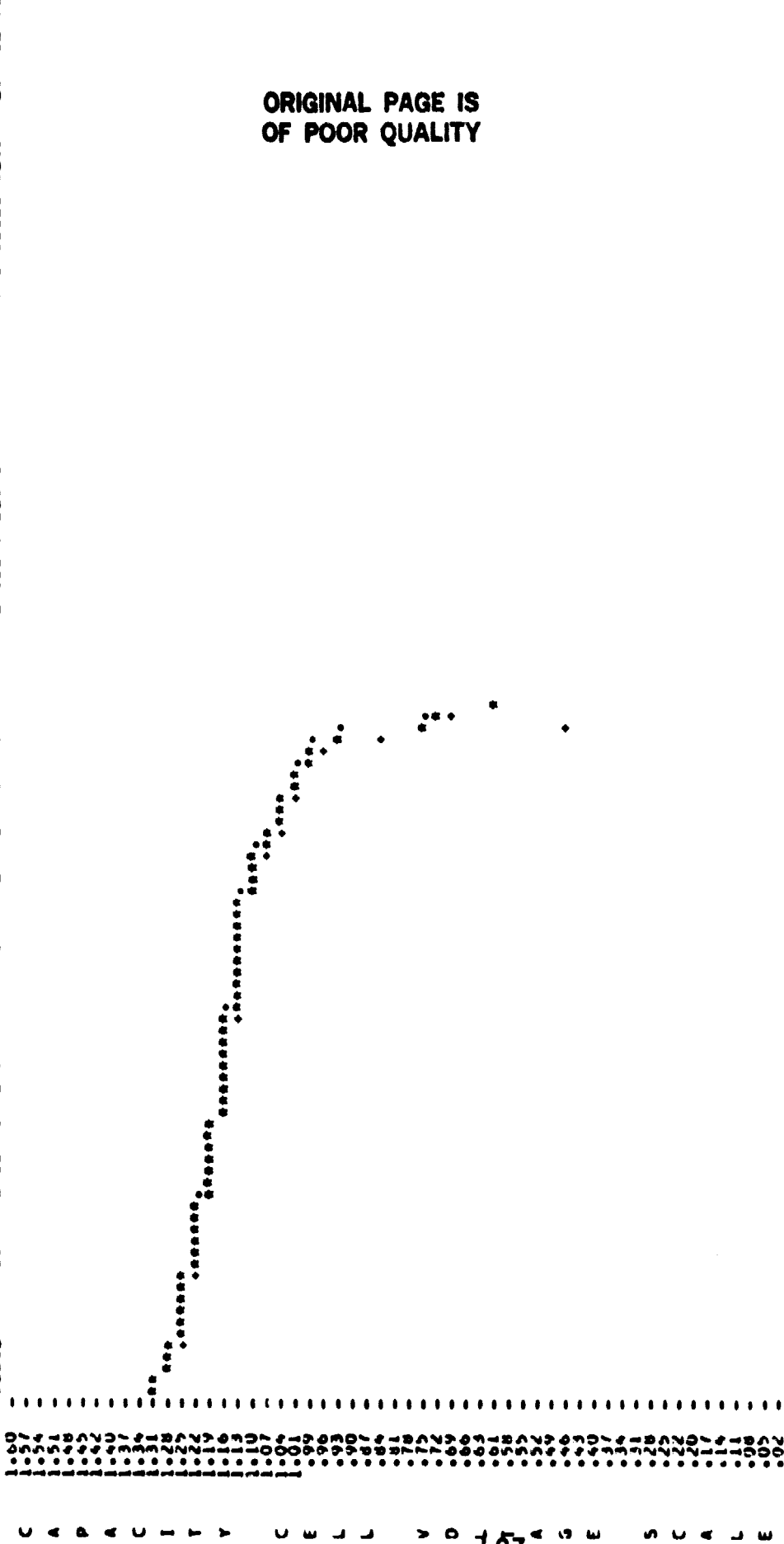
ORIGINAL PAGE IS
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KEY
* HIGH CELL
* LOW CELL
* AVERAGE

PACK NUMBER IS 2298
SHADOW PERIOD IS 03
CYCLE NUMBER IS 387
DISCHARGE RATE IS 10.

20 2.62 3.05 7.47 9.89 12.33 14.74 17.17 19.59 22.02 23.73
1. 1. 3.83 6.26 8.68 11.11 13.53 15.96 18.38 20.80 23.23

AMPERE HOUR OUT



CELLS INCLUDED V-3 V-4 V-5

FIGURE 331

AMPERE HOUR OUT

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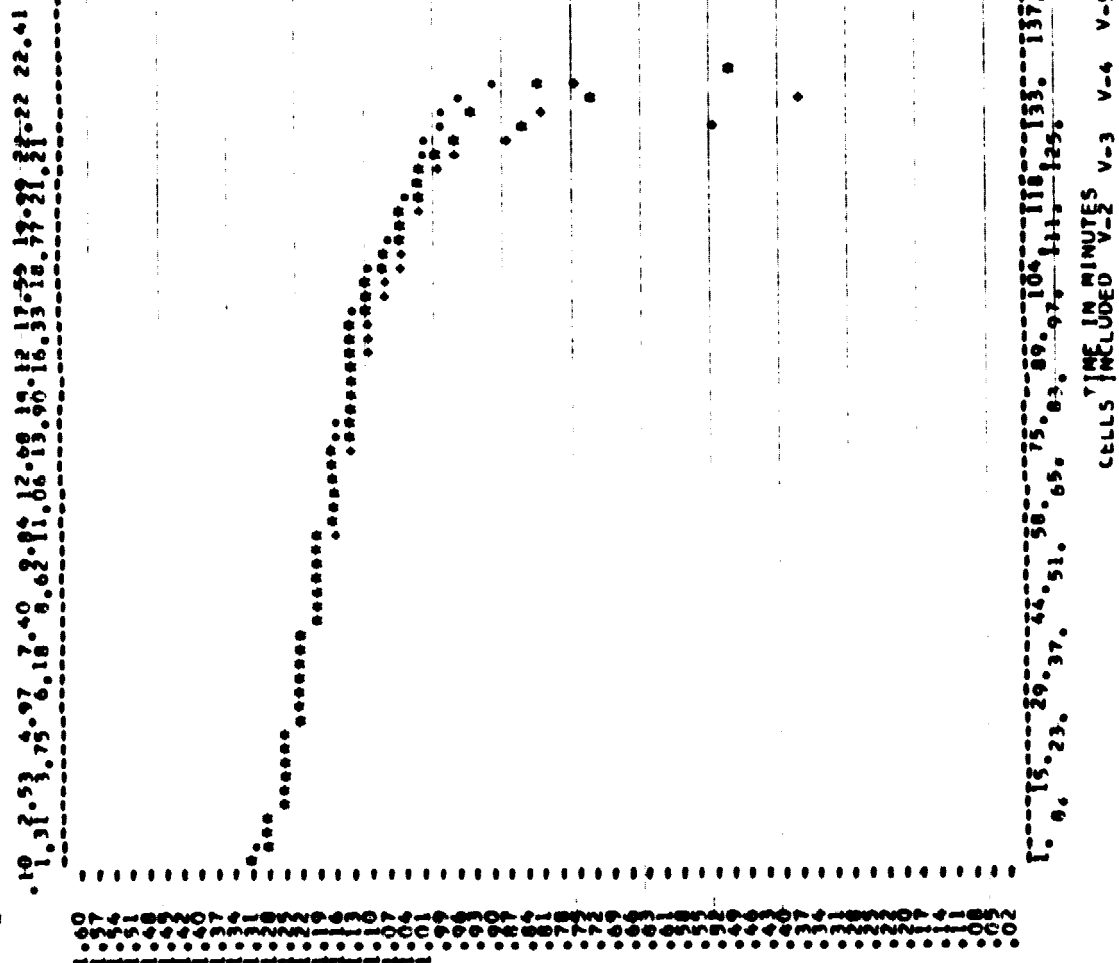


FIGURE 332

PACK NUMBER IS 229R
 SHOWN DEGREE IS 5
 CYCLE NUMBER IS 753
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

C A P A C I T Y C E L L V O L T A G E S C A L E

ORIGINAL PAGE IS
 OF POOR QUALITY

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 333

3-ACC. PERIOD IS 36
CYCLE NUMBER IS 935
DISCHARGE RATE IS 10.

AMPERE HOUR OUT

• AVERAGE
• LOW CELL
• HIGH CELL

[illegible]

410

| | TIME IN MINUTES | | CELLS INCLUDED | Y-5 | | | | | | |
|----|-----------------|-----|----------------|-----|-----|-----|------|------|------|------|
| 1. | 16. | 30. | 45. | 59. | 73. | 88. | 102. | 117. | 131. | 136. |
| 9. | 23. | 37. | 52. | 66. | 81. | 96. | 109. | 124. | | |

FIGURE 334

DEPTH DISCHARGE 60
TEMPERATURE 20
TEMPERATURE RATE 20
SPRINTAL 2653, 2669, 2670, 2676, 722
SAFE CELLS
PROJECT

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 229B

KEY
1 AHO
2 AHI_TOTAL
3

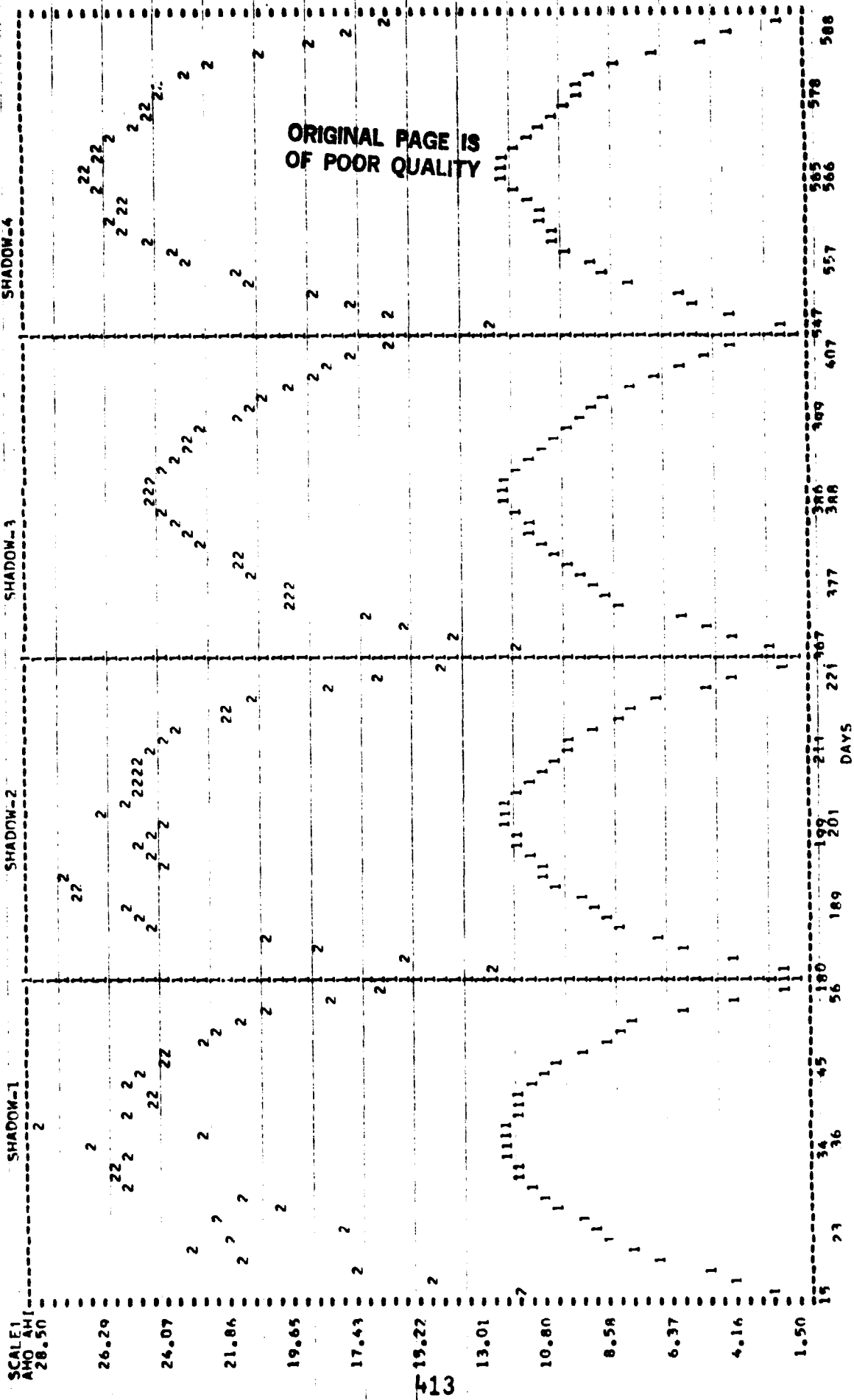


FIGURE 337

KEY
1 AMO
2 AMI-TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 30
SERIAL 2653, 2669, 2670, 2676, 722
SAFT CELLS
PROJECT

PACK = 2298

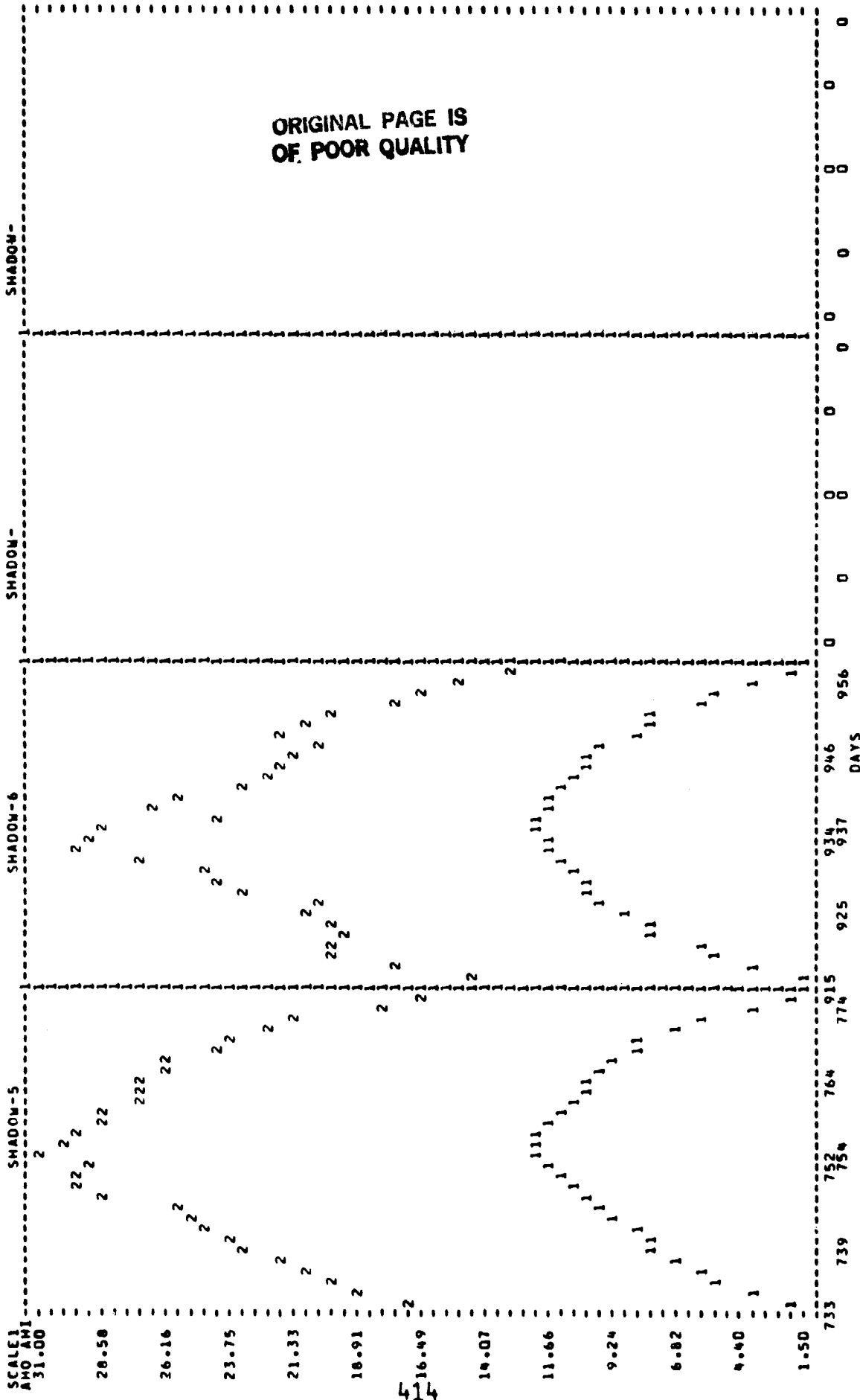


FIGURE 338

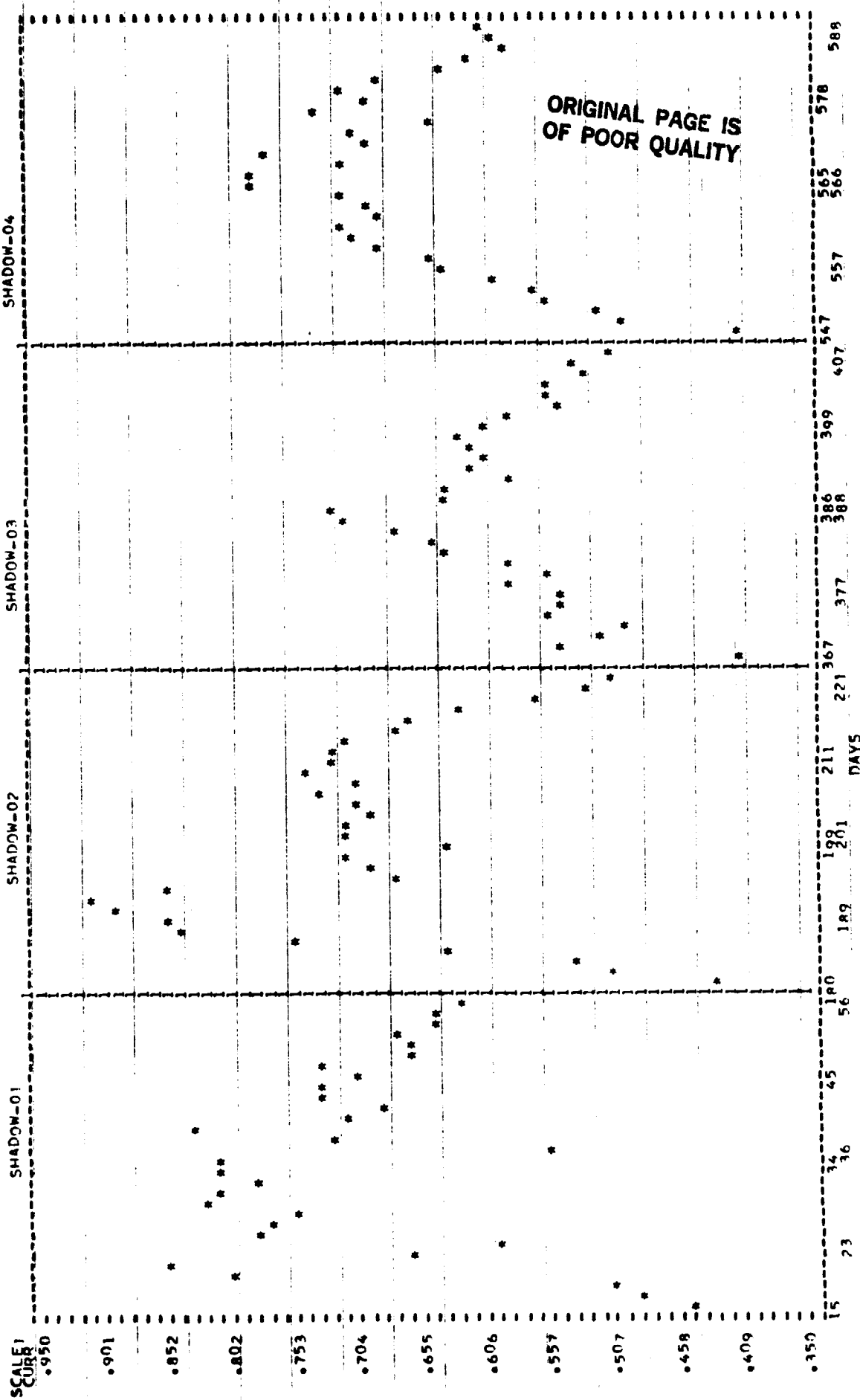
KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 2653, 2669, 2670, 2676, 722

PROJECT :
SAFETY CELLS

PACK = 2298



DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 2653,2669,2670,26767722

SYNCHRONOUS 1/2BIT SHADOW PLOT

PROJECT
SAFT CELLS

PACK = 229B

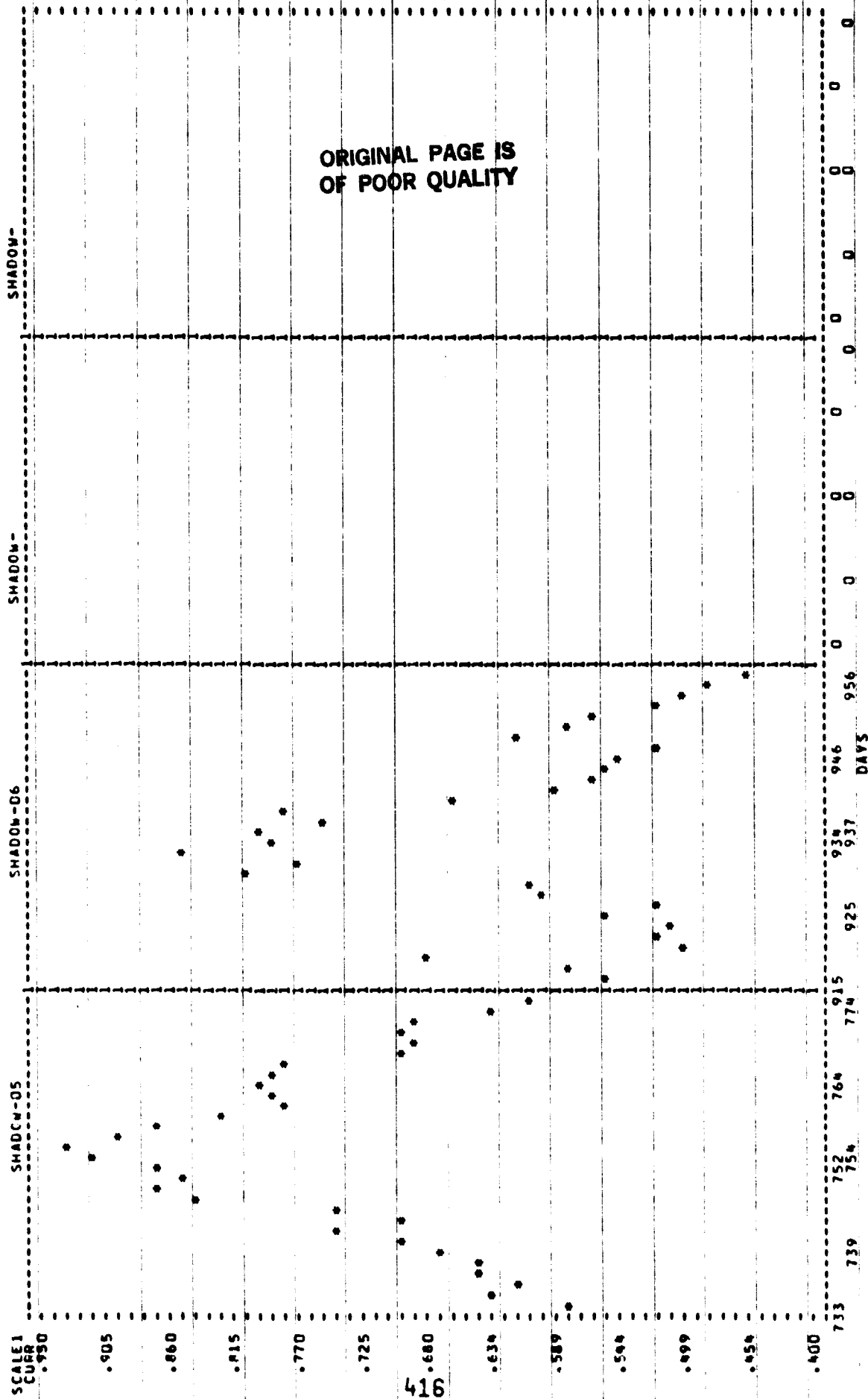


FIGURE 340

L. YD 20.0 ah

1. Pack 229D, 5-cells

a. Cell information: These cells did not meet GSFC's requirements as a standard cell. The cells were manufactured for NASA, GSFC, under NASA contract number NAS 5-22461 according to the manufacturer's Manufacturing Control Document (MCD) MCD 21406, whose design was intended to meet the requirements of GSFC's specification 74-15000 with amendments. The cells have electrochemically impregnated electrodes and were identified by the manufacturer's model numbers YNC 20-1/20-2 and part numbers 14188/14178 with one cell having an auxiliary electrode. Cell 2 was fitted with a pressure transducer prior to testing. Initial evaluation test results are contained in NAVWPNSUPPCEN Crane Report WQEC/C 79-144. Cells, of this type, are being evaluated on near-earth orbit test regimes.

b. Parameters:

| | | | |
|--------------------------|-------|----------------------|-----|
| Depth of Discharge (%) | 60 | Temperature (°C) | 20 |
| Charge Control | VL | Float Current (amps) | .33 |
| Charge Current (amps) | 2.00 | Auxiliary Electrode* | |
| Discharge Current (amps) | 10.00 | Resistance (ohms) | 47 |
| Voltage Limit (v/c) | 1.414 | | |

*--Cell 5

c. Capacity Checks: (Discharge each cell to .75 volts)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah
<u>out</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Precycling (Figure 341) | 1.143 | .682 | 1.157 | 1.008 | 1.123 | 21.08 |
| Shadow 1 (Figure 342) | | | | | 24.14 | |
| Shadow 2 (Figure 343) | | | | 21.91 | 24.10 | |
| Shadow 3 (Figure 344) | | | 23.76 | 21.45 | 24.37 | |
| Shadow 4 (Figure 345) | | 23.47 | 21.80 | 21.40 | 24.76 | |
| Shadow 5 (Figure 346) | 24.00 | 22.69 | 21.68 | 22.19 | ** | |
| Shadow 6 (Figure 347) | | | | 23.06 | | |

**--Cell 5 shorted during charge following shadow 4's capacity check (day 567).

d. Test results during the Shadow Period: (Figures 348 to 353)

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.178 (shadow 1) to 1.142 volts (shadow 5) before it was capacity checked, with the largest decrease (22 mv) being from shadow 1 to 2. The reconditioning effect on the voltages of those cells, which were capacity checked, during shadows 1 and 2, were not noticeable from one mid-shadow to another until shadow 3 when the voltage of these cells averaged 6 mv higher than the other cells. This average was 13 mv during

shadow 5. The mid-shadow voltage of cell 5, which received a capacity check each shadow until it shorted following shadow 4's capacity check, had averaged 1.156 volts from shadow 2 to 4. Cell 4, which is now being capacity checked each shadow, has had a mid-shadow voltage of 1.156 volts the last three shadows. The decrease in voltages, the day following the capacity checks, is due to those cells being an open-circuit for 24 hours during these checks.

(2) Capacity/Reconditioning Effects: The capacity of cell 5 had increased from 24.14 ah (shadow 1) to 24.76 ah (shadow 4) before it shorted; but its voltage degradation had resulted in a 19.4 percent decrease in capacity available to 1.10 volts and a 4.5 percent decrease to 1.00 volts with the largest percent decreases occurring between shadows 1 and 2. A capacity check each shadow has decreased the rate of voltage degradation following the characteristic decrease from shadow 1 to 2, although the input prior to these checks has not been less than 29 ah and was above 32 ah the last two shadows.

(3) End of Charge Voltages and Pressures: Minimum unbalance (3 to 5 mv) occurred the first 5 days of shadow 1 and the first half of shadow 5. Maximum unbalance (12 to 16 mv) occurred during the first 4 shadows with cell 5 having the lowest voltage and cell 4 the highest. After cell 5 shorted, cell 1 became the low cell while cell 4 remained the high. During the last shadow, there was an 8 mv difference between the high and low cells at mid-shadow. The mid-shadow pressure (cell 2) has increased from 7 psia (shadow) to 10 psia (shadow 6).

(4) Ampere-Hour Input: The mid-shadow input has ranged from 29.2 ah (shadow 3), with the pack temperature during charge not exceeding 21.9°C, to 33.8 ah (shadow 5) with the peak pack temperature being 25.4°C. Maximum input followed the capacity check of shadow 5, in which all the cells were checked. The pack's temperature exceeded 25°C during the second half of shadow 1 and it was assured, at this time, that the pack's position in the environmental chamber was receiving the proper air circulation.

e. Performance during Sun Periods: Pack has completed five sun periods as it began test with a shadow period. The pressure has not exceeded 9 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period. Also, the current is listed when it was less than .33 amps due to the pack's voltage limit.

| | 1 | | 2 | | 3 | |
|-------------------|-----------|-----------|-------------|-----------|-----------|-----------|
| <u>Voltages**</u> | Start | End | Start | End | Start | End |
| High | 1.401 (4) | 1.419 (4) | 1.404 (2,4) | 1.410 (2) | 1.403 (4) | 1.418 (2) |
| Average | 1.395 | 1.414 | 1.400 | 1.407 | 1.398 | 1.414 |
| Low | 1.385 (5) | 1.406 (5) | 1.391 (5) | 1.401 (5) | 1.390 (5) | 1.405 (5) |
| Current | | | | | | .26 |

| | 4 | | 5 | |
|-----------------|-----------|-------------|-----------|-----------|
| <u>Voltages</u> | Start | End | Start | End |
| High | 1.400 (4) | 1.405 (4) | 1.409 (4) | 1.418 (3) |
| Average | 1.398 | 1.404 | 1.405 | 1.414 |
| Low | 1.396 (1) | 1.403 (1,2) | 1.401 (1) | 1.407 (2) |
| Current | | | | .30 |

**--() indicates which cell

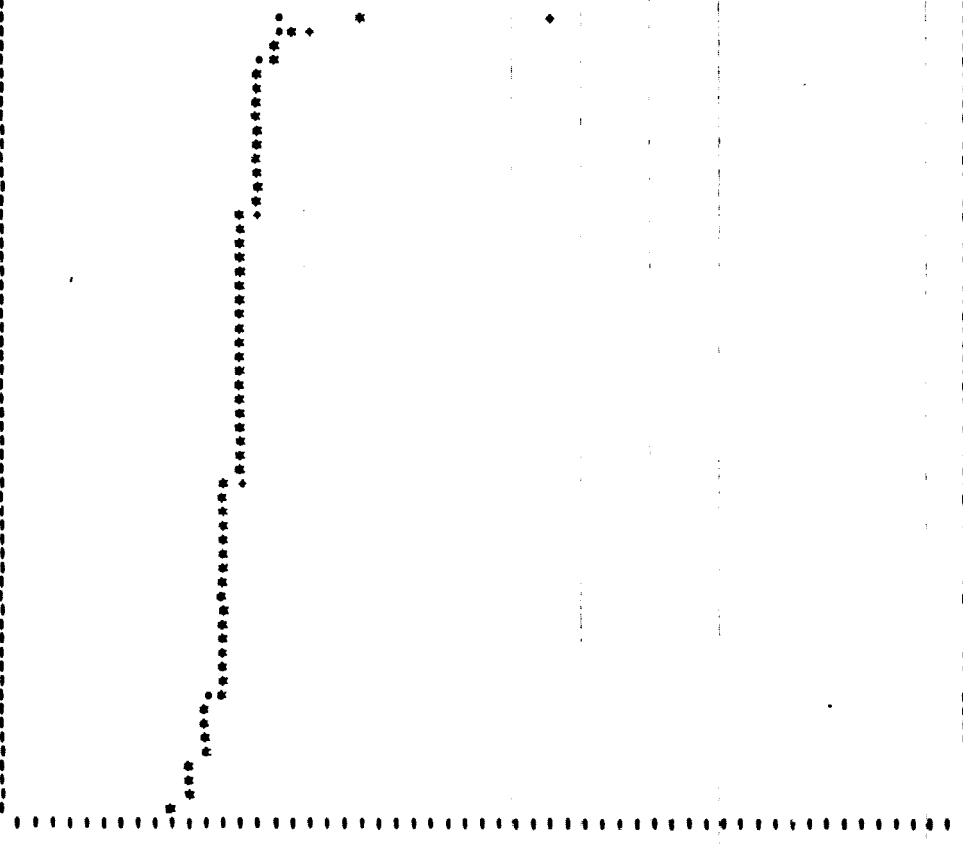
100% CELL
AVERAGE

PRE-CYCLING
CYCLE NUMBER IS 10
DISCHARGE RATE IS 10.

AMPERE HOUR OUT

1.26 2.12 4.17 6.49 8.54 10.91 13.26 15.62 17.96 20.31 21.08
3.00 5.34 7.65 9.72 12.09 14.44 16.79 19.14

C A P A C I T Y C E L L V O L T A G E S C A L E



1.10 1.17 2.30 3.00 4.50 5.70 6.40 7.10 7.90 8.70 9.30 10.70 11.50 12.90 13.40

TIME IN MINUTES
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 341

ORIGINAL PAGE IS
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PACK NUMBER IS 2290
 SHADOW PERIOD IS 1 35
 CYCLE NUMBER IS 10
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

20 2.63 5.03 7.43 9.82 12.21 14.61 16.99 19.38 21.76 24.14
 1.42 3.83 6.23 8.63 11.02 13.41 15.80 18.19 20.57 22.95

C A P A C I T Y C E L L V O L T A G E S C A L E

ORIGINAL PAGE IS
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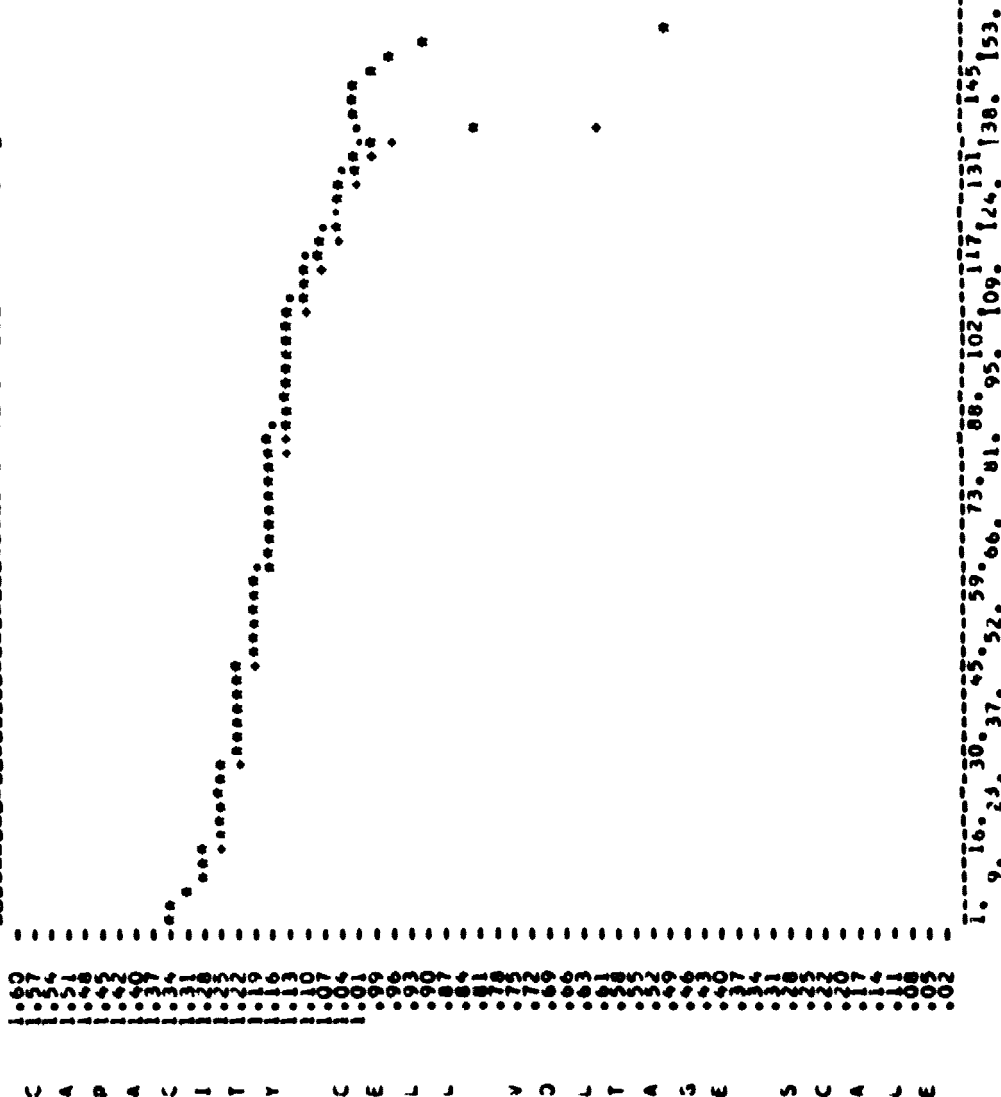
1. 16. 31. 37. 44. 52. 59. 66. 73. 80. 88. 95. 102. 109. 116. 124. 131. 138. 145.

TIME IN MINUTES
 CELLS INCLUDED V-5

ACCOUNT NUMBER 12 3200
ESTIMATED PERIOD IS 02
CYCLE NUMBER IS 00
DISCHARGE RATE IS 10.

AMPERE HOUR OUT

**ORIGINAL PAGE IS
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TIME IN MINUTES
CELLS INCLUDED V-4 V-5

ORIGINAL PAGE IS
OF POOR QUALITY

KEY
* HIGH CELL
* LOW CELL
* AVERAGE

PACK NUMBER IS 2290
SHADOW PERIOD IS 03
CYCLE NUMBER IS 387
DISCHARGE RATE IS 10.
30 2.09 5.07 7.46 9.85 12.75 14.65 17.05 19.45 21.75 23.96 24.37
1.50 3.08 6.26 8.65 11.05 13.45 15.85 18.25 20.65 22.96

AMPERE HOUR OUT

C 1.57
A 1.54
P 1.51
A 1.48
C 1.42
C 1.40
C 1.37
C 1.34
C 1.31
C 1.28
C 1.25
C 1.22
C 1.19
C 1.16
C 1.13
C 1.10
C 1.07
C 1.04
C 1.01
C .99
C .96
C .93
C .90
C .87
C .84
C .81
C .78
C .75
C .72
C .69
C .66
C .63
C .61
C .58
C .55
C .52
C .49
C .46
C .43
C .40
C .37
C .34
C .31
C .28
C .25
C .22
C .19
C .16
C .13
C .11
C .08
C .05
C .02

1. 8. 16. 23. 30. 37. 44. 52. 60. 66. 73. 80. 88. 95. 102. 109. 116. 124. 136. 143. 150. 152.

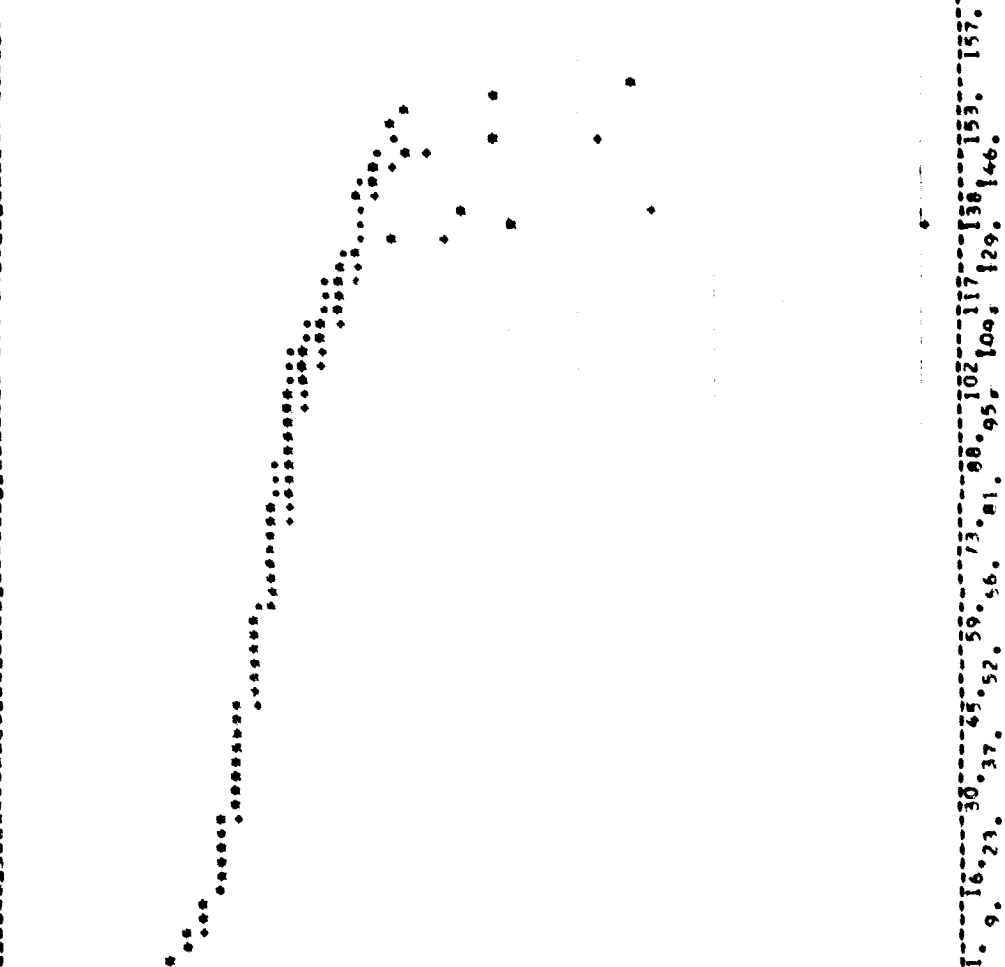
TIME IN MINUTES
CELLS INCLUDED V-3 V-4 V-5

FIGURE 344

ANYWHERE HOUR OUT

[illegible][illegible]

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OF POOR QUALITY



| TIME IN MINUTES | | V-3 | | V-4 | | V-5 | |
|-----------------|-----|-----|----|-----|----|-----|----|
| CELLS INCLUDED | V-2 | | | | | | |
| 1 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 3 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 4 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 5 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 6 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 7 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 8 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 13 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 14 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 15 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 16 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 17 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 18 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 19 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 20 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 21 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 22 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 23 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 24 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 25 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 26 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 27 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 28 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 29 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 30 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 31 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 32 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 33 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 34 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 35 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 36 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 37 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 38 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 39 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 40 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 41 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 42 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 43 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 44 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 45 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 46 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 47 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 48 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 49 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 50 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 51 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 52 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 53 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 54 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 55 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 56 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | | | | | | |

FIGURE 345

LOG TIME
AVERAGE

CYCLE NUMBER IS 425
DISCHARGE RATE IS 10.

AMPERE HOUR OUT

30. 2.72 5.12 7.52 9.92 12.31 14.70 17.09 19.48 21.87
1.51 3.92 6.32 8.72 11.12 13.51 15.90 18.29 20.68 23.06

C 1.57
A 1.51
P 1.49
A 1.47
C 1.45
I 1.43
T 1.41
Y 1.39
C 1.37
E 1.35
L 1.33
L 1.31
V 1.29
O 1.27
L 1.25
T 1.23
A 1.21
G 1.19
E 1.17
S 1.15
C 1.13
A 1.11
L 1.09
E 1.07

1. 8. 16. 23. 30. 37. 44. 51. 59. 66. 73. 80. 88. 95. 102. 109. 116. 124. 131. 138.

TIME IN MINUTES
CELLS INCLUDED V-4

FIGURE 347

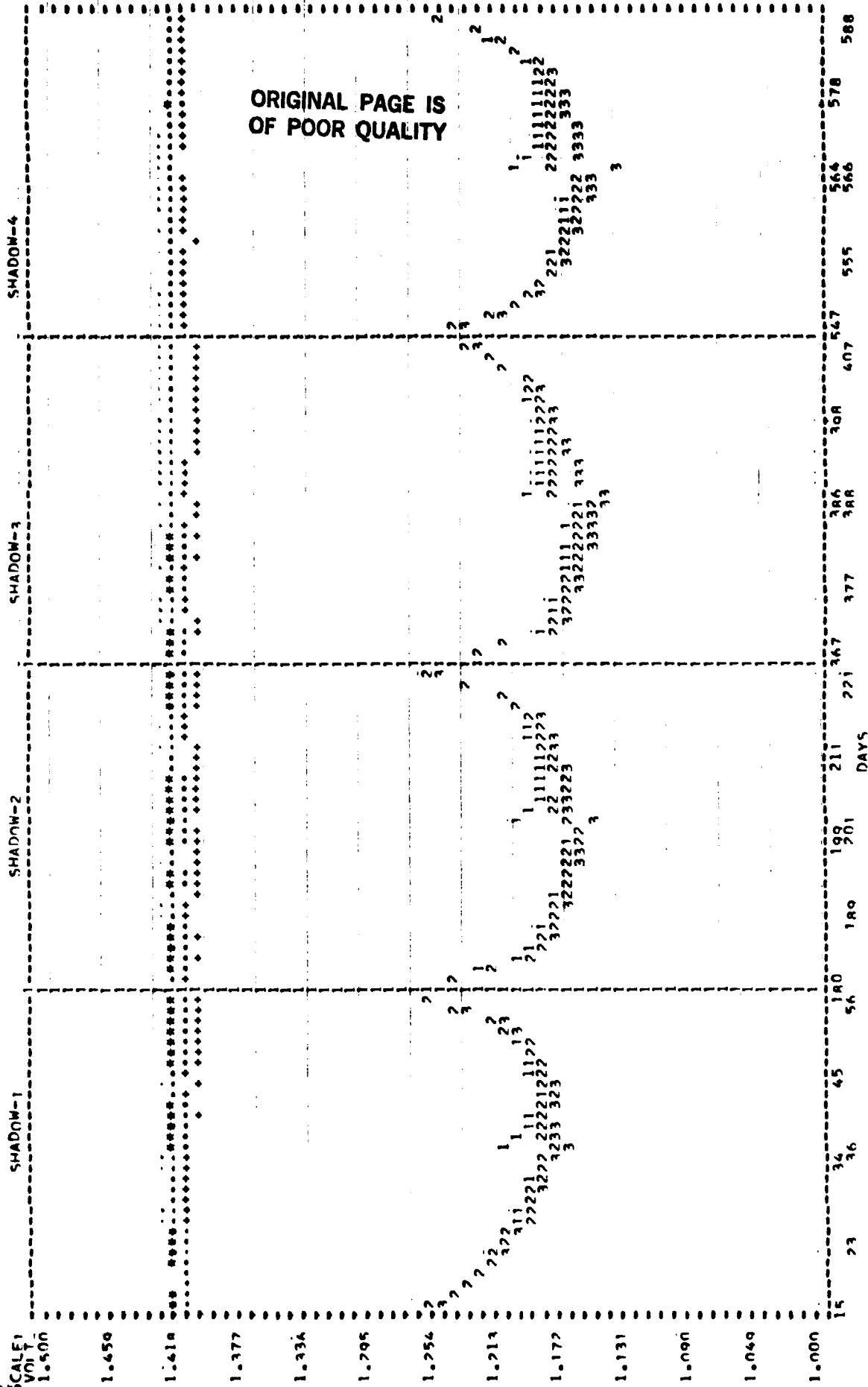
ORIGINAL PAGE IS
OF POOR QUALITY

KEY
1 HIGH FND DISCHARGE VOLTAGE
2 AVE FND DISCHARGE VOLTAGE
3 LOW FND DISCHARGE VOLTAGE
4 HIGH FOC
5 AVE FOC
6 LOW FOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
YARDNEY CFLLS
PROJECT 81-60-03-71-30
SERIAL 01

PACK = 229D



ORIGINAL PAGE IS
OF POOR QUALITY

KEY
1 HIGH END DISCHARGE VOLTAGE
2 AVE END DISCHARGE VOLTAGE
3 LOW END DISCHARGE VOLTAGE
• AVE EOC
• LOW EOC
X Y Z

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
YARDNEY CELLS

PROJECT
SERIAL 01.60.03.71.30

PACK = 2290

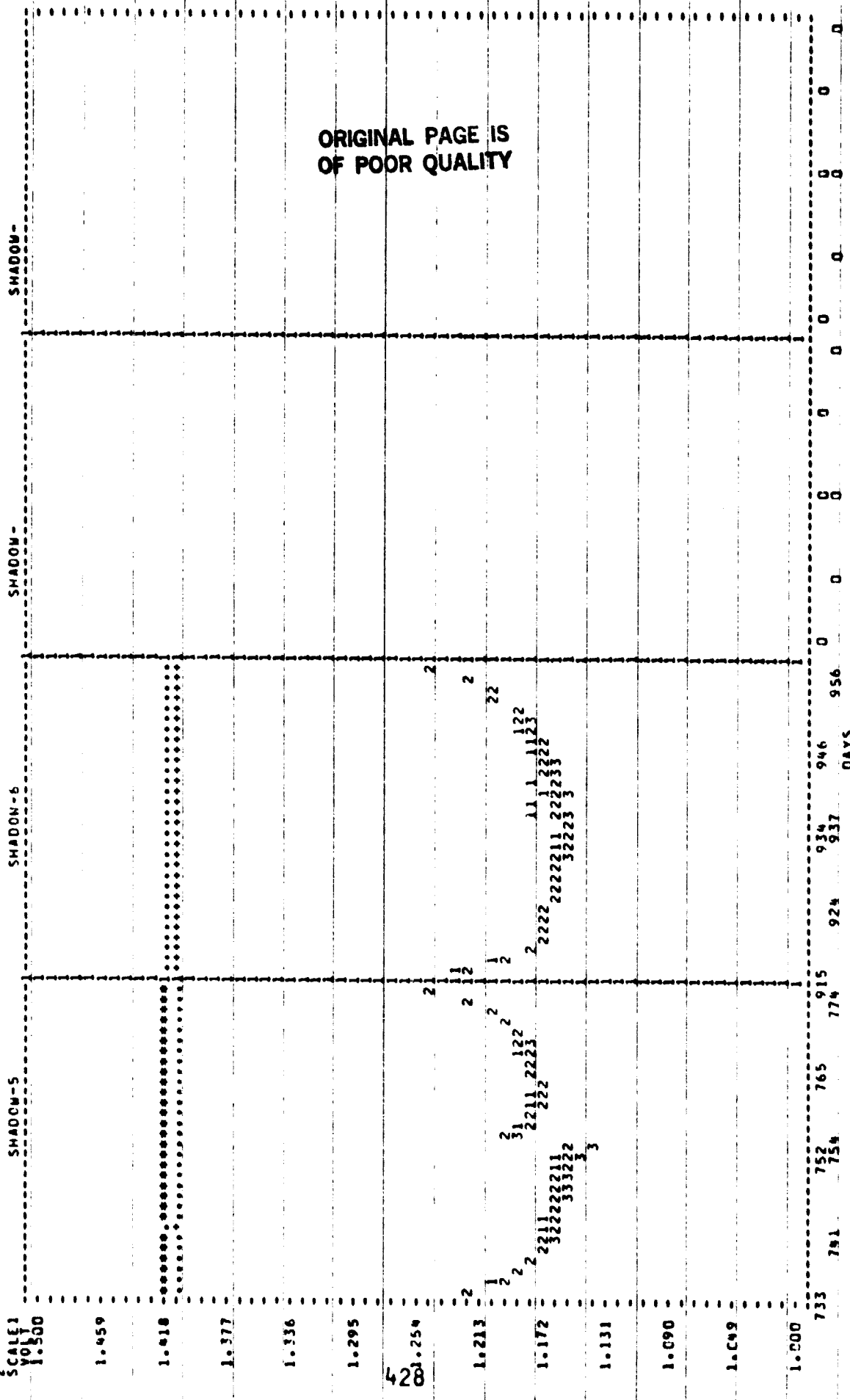


FIGURE 349

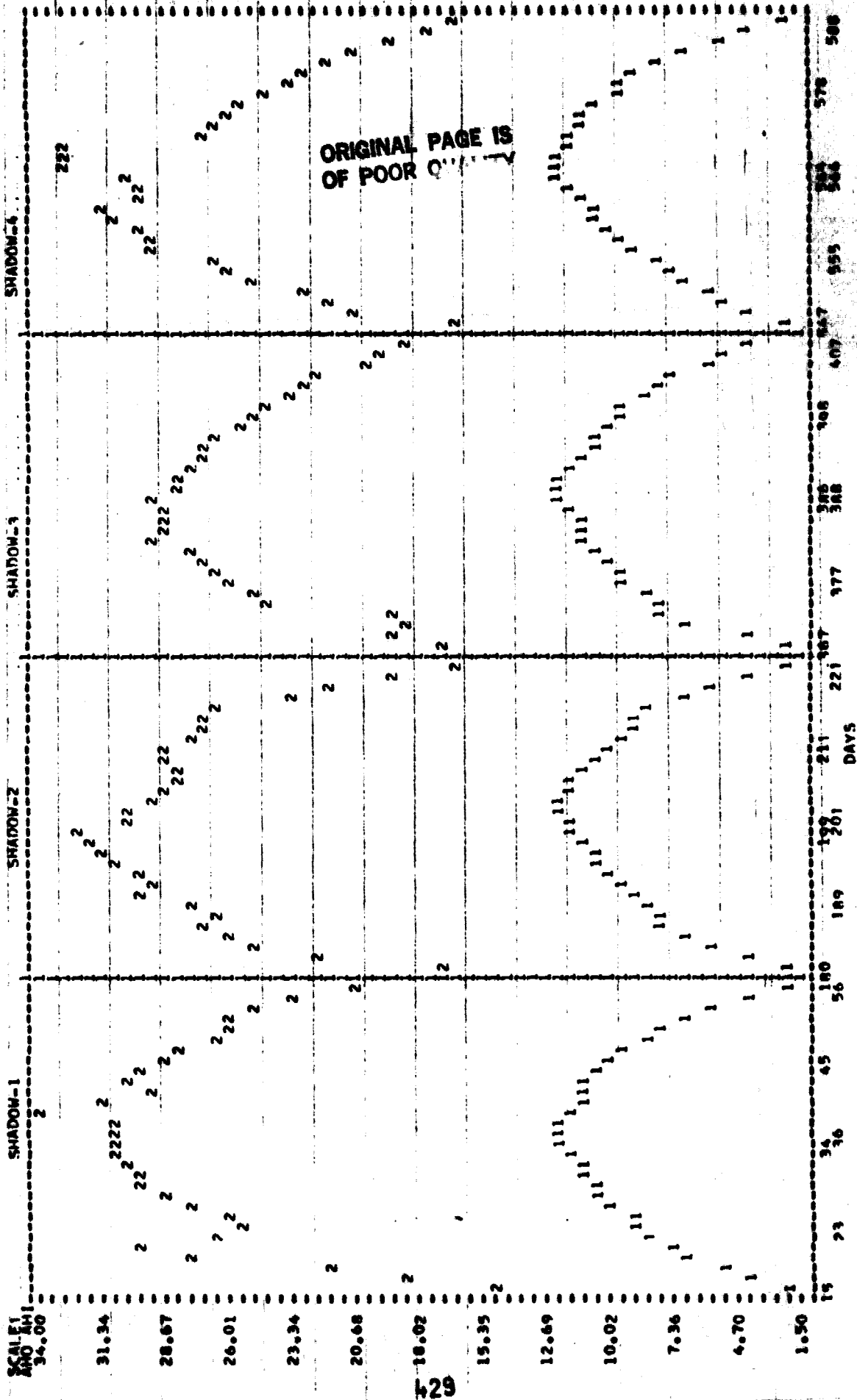
KEY
1 AMI-TOTAL
2

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SPRIT 101 0003 71-30
VARNISH 7-11-5

SYNCHRONOUS ORBIT SHADOW PL-7

PROJECT :

PACK = 229D



KEY
1 AMI-TOTAL
2 AMI

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
APPROX DATE 20
SERIAL 01-60-03-11350
PROJECT - PAROLEE CALLS

PACK - 2290

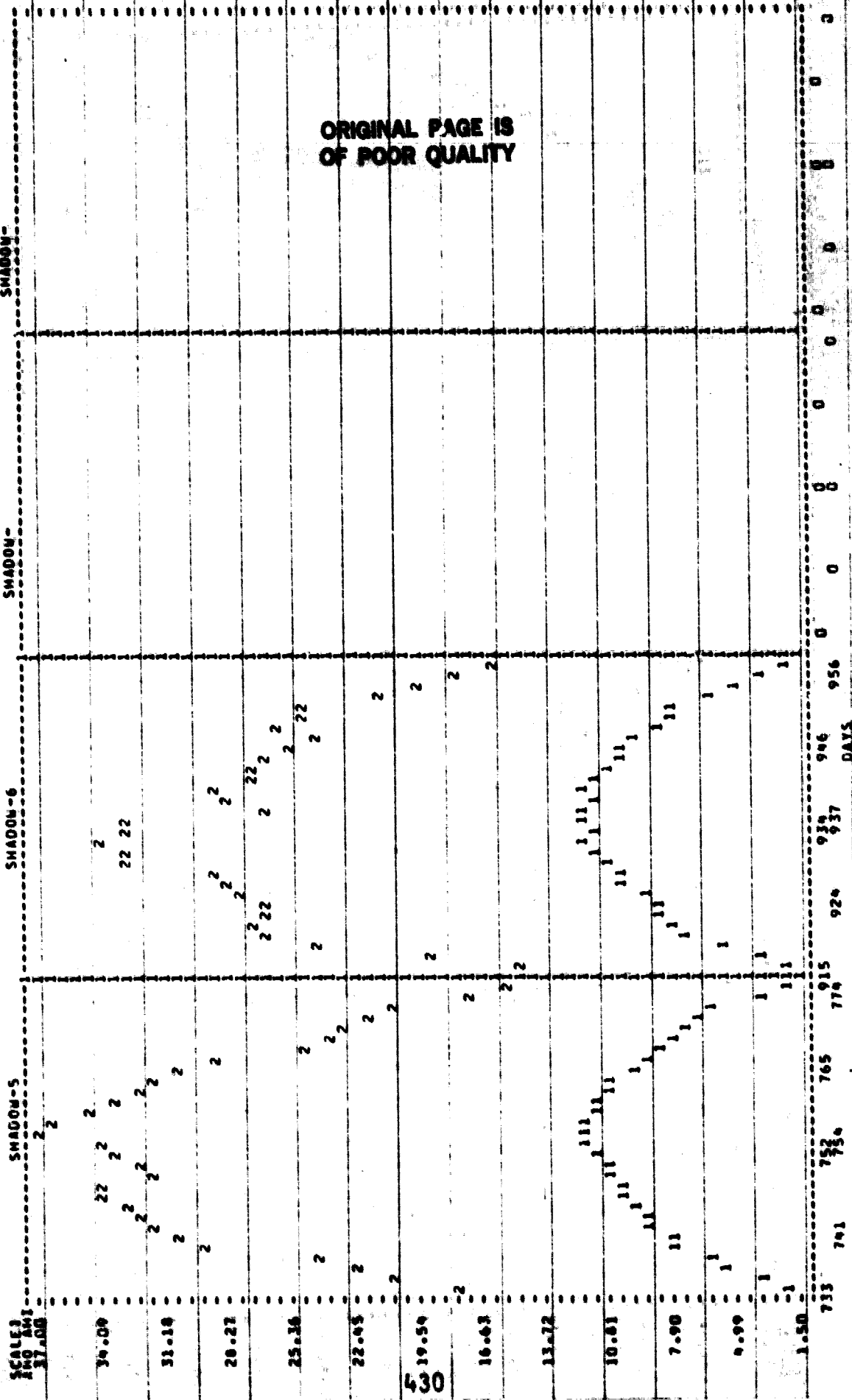


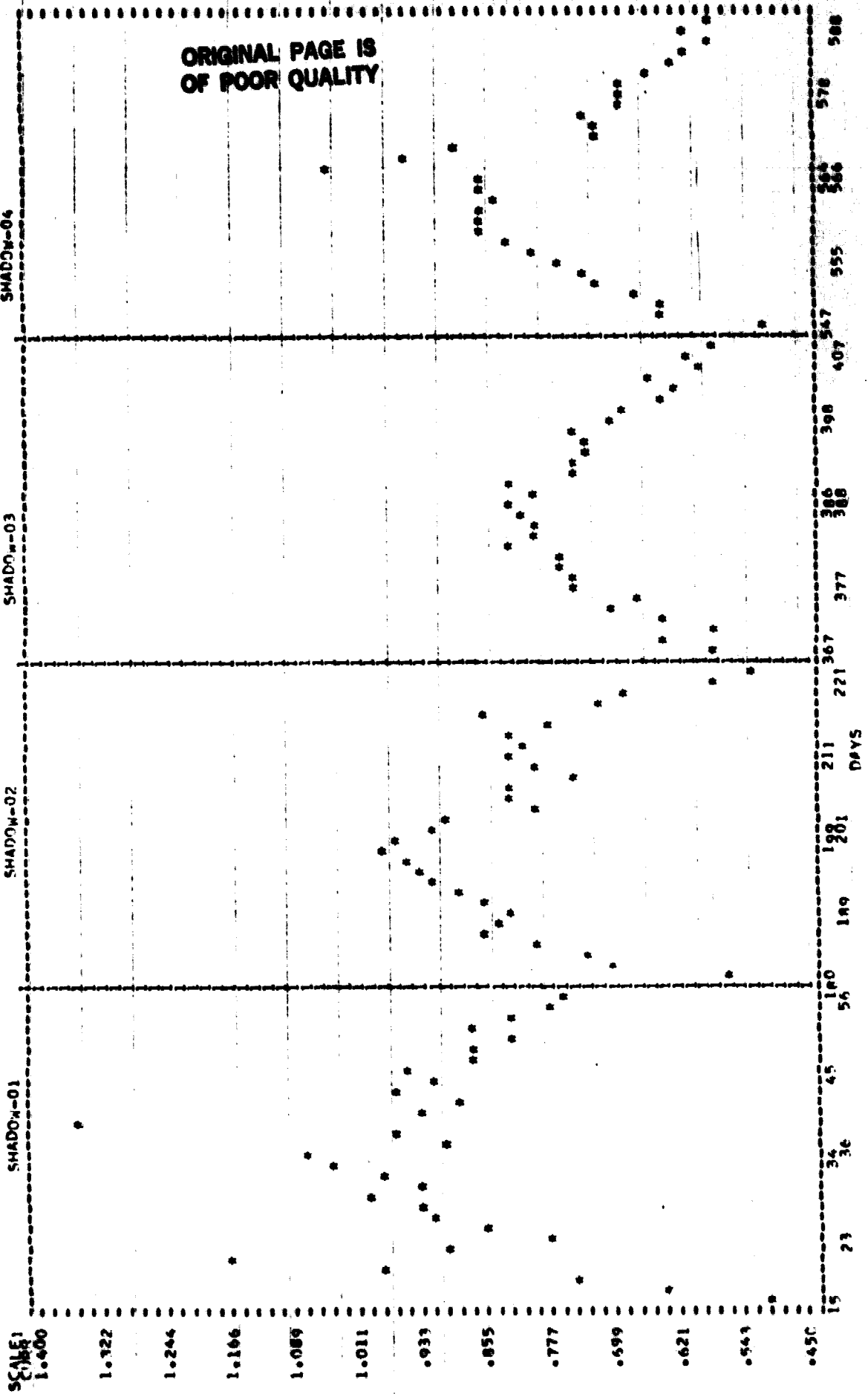
FIGURE 351

KEY
● END CHARGE CURRENT

SYNCHRONOUS OPBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 01.60.03.71.30
PROJECT 1

PACK = 2290



KEY
• LEAD CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 01.60003.71.30

PROJECT - YD CELLS

PACK = 220C

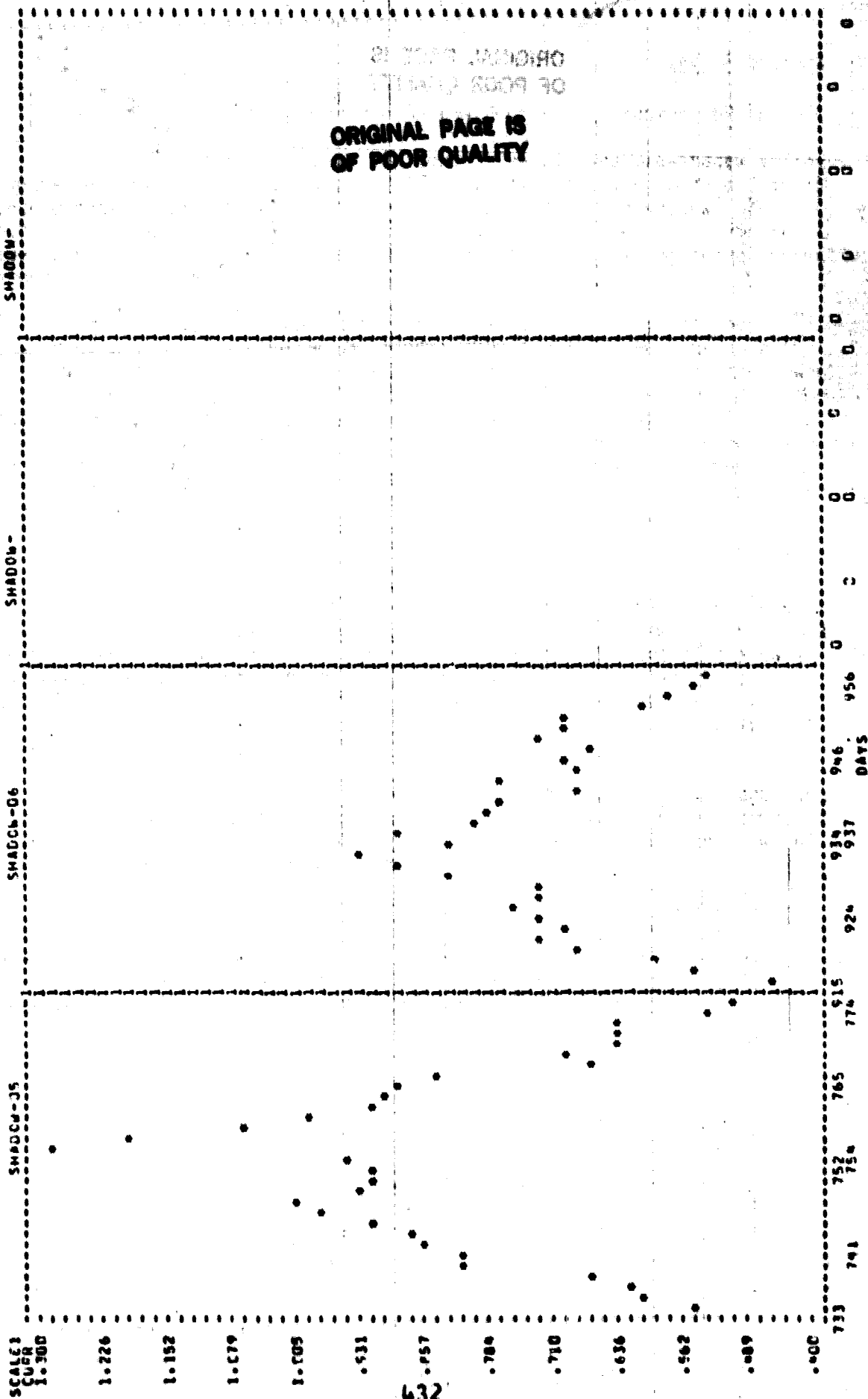


FIGURE 353

M. GE 40.0 ah (TDRSS)

1. Pack 232A, 5-cells

a. Cell information: The cells were manufactured for TRN at the same time and from the same materials as Engineering Cells (Lot 1) manufactured for the Tracking Data Relay Satellite System (TDRSS) program. They were manufactured in accordance with TRN Part/Material Control Document "Battery Cells 40 ah", Number 8E011 and General Electric MCD 232A2222AA-80. The cells were identified by the manufacturer's catalog numbers 42B040AB03-G1 and G2. These cells are rated at 40.0 ampere-hours, contain double ceramic seals, and the G2 type cells (4 and 5) were fitted with pressure transducers prior to testing. Initial evaluation test results are contained in NAVWPNSUPPCEN Crane Report WQEC/C 78-416.

b. Parameters:

| | | | |
|------------------------|----|--------------------------|-------|
| Depth of Discharge (%) | 50 | Discharge Current (amps) | 16.67 |
| Charge Control | CC | Temperature (°C) | 0 |
| Charge Current (amps)* | | Float Current (amps) | .27 |

*-- In-rush current, for 10 minutes following discharge, is 21 amps for days 20, 21, 22, 23, and 24; and 12 amps for the other days. The current is then reduced to 2.67 amps until the percent recharge is 106 (110 prior to shadow 4) at which time the current is reduced to .27 amps. The pack receives a 6 amp charge for 10 minutes the day prior to and following each shadow period.

c. Capacity Check/Reconditioning: (Discharge to .75 volts any cell prior to every fourth shadow. Reconditioning is performed, prior to the other shadows, by placing a 16-ohm resistor across the pack until the pack voltage is .40 volts. This is also done following the capacity check.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | <u>ah</u> |
|-------------------------|------------------|------------------|------------------|------------------|------------------|-----------|
| Precycling (Figure 354) | .749 | .809 | 1.100 | .974 | 1.142 | 50.30 |
| Recond 2 (Figure 355) | .036 | -.070 | -.067 | .389 | .718 | 60.62 |
| Recond 3 (Figure 356) | .280 | .128 | .242 | .589 | .700 | 61.30 |
| Shadow 4 (Figure 357) | .963 | .656 | 1.060 | .852 | 1.109 | 47.75 |
| Recond 5 (Figure 358) | -.080 | -.081 | -.074 | -.048 | .696 | 58.74 |
| Recond 6 (Figure 359) | -.134 | -.134 | -.131 | .053 | .748 | 64.33 |

d. Test results during the Shadow Periods: (Figures 360 to 363)

(1) End of Discharge Voltages: The average mid-shadow voltages have decreased from 1.209 (shadow 1) to 1.198 volts (shadow 6) with a 3 mv difference between the high (5) and low (1,2) cells the last shadow. The largest decrease was from shadow 1 to 2 which was 7 mv. The slight dip in voltages during the last shadow (day 865) is due to the pack not being correctly recharged the previous day.

(2) Capacity/Reconditioning Effects: Capacity obtained during the last reconditioning discharge was higher than the first two, because the first two were terminated prior to the .4 volt pack voltage. Also, the lower output obtained during Recond 5 is due to the test temperature being 25°C for 60 hours. This occurred 52 hours after the discharge had started. The capacity to 1.00 v/c average was 60 ampere-hours during the last reconditioning discharge. Cell 5 has never been discharged below .69 volts and it has the highest EOD shadow voltages. Any reconditioning effect, due to the daily discharges, is not noticeable.

(3) End of Charge Voltages and Pressures:

(a) 2.67 ampere-rate---The average mid-shadow voltages have steadily increased from 1.496 (shadow 1) to 1.519 volts (shadow 6) even though the percent recharge was decreased from 110 to 106 at the start of shadow 4. The difference between the high cell (5) and low cell (1) voltages has also steadily increased from 3 mv the first shadow to 34 mv the last, with cells 5 and 1 being 1.542 and 1.508 volts. The pressures have also increased from 20 to 31 psia.

(b) .26 ampere-rate---The average mid-shadow voltages and pressures were 1.436 volts and 33 psia during shadow 6 which is an increase of 8 mv and 17 psia from shadow 1. The difference between the high and low cells was 2 and 5 mv for the first and last shadows.

(c) 6.0 ampere-rate---The average voltages prior to the start of the shadow periods have been approximately 1.558 volts; but the voltages following the shadow periods have increased from 1.545 (shadow 1) to 1.578 volts (shadow 6), with the high cell (5) increasing from 1.548 to 1.605 volts and the low cell (1) increasing from 1.537 to 1.563 volts.

e. Performance during Sun Periods: Pack has completed five sun periods, with period 1 being only 2 months, as it began test with a shadow period. The pressures have not exceeded 37 psia (end of period 3) during these periods and cell 4's pressure was 32 psia at the end of period 5. Following is a listing of the high, average, and low voltages at the start and the end of each sun period prior to reconditioning.

| <u>Voltages*</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
|------------------|--------------|---------------|--------------|-------------|---------------|-------------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| High | 1.428 (5) | 1.446 (1,2,5) | 1.430 (1) | 1.460 (4) | 1.441 (5) | 1.463 (5) |
| Average | 1.427 | 1.446 | 1.428 | 1.449 | 1.440 | 1.461 |
| Low | 1.426 (3) | 1.445 (3,4) | 1.427 (4) | 1.446 (1,3) | 1.439 (1,3,4) | 1.460 (1,3) |

| <u>Voltages</u> | <u>Start</u> | <u>End**</u> | <u>Start</u> | <u>End</u> |
|-----------------|------------------|---------------|--------------|------------|
| | 4 | 5 | 6 | 7 |
| High | 1.447 (2,5) | 1.427 (2,5) | 1.442 (5) | 1.454 (2) |
| Average | 1.446 | 1.426 | 1.440 | 1.453 |
| Low | 1.445
(1,3,4) | 1.426 (1,3,4) | 1.438 (1) | 1.452 (4) |

*--() indicates which cell

**-- current was .15 instead of .27 amps

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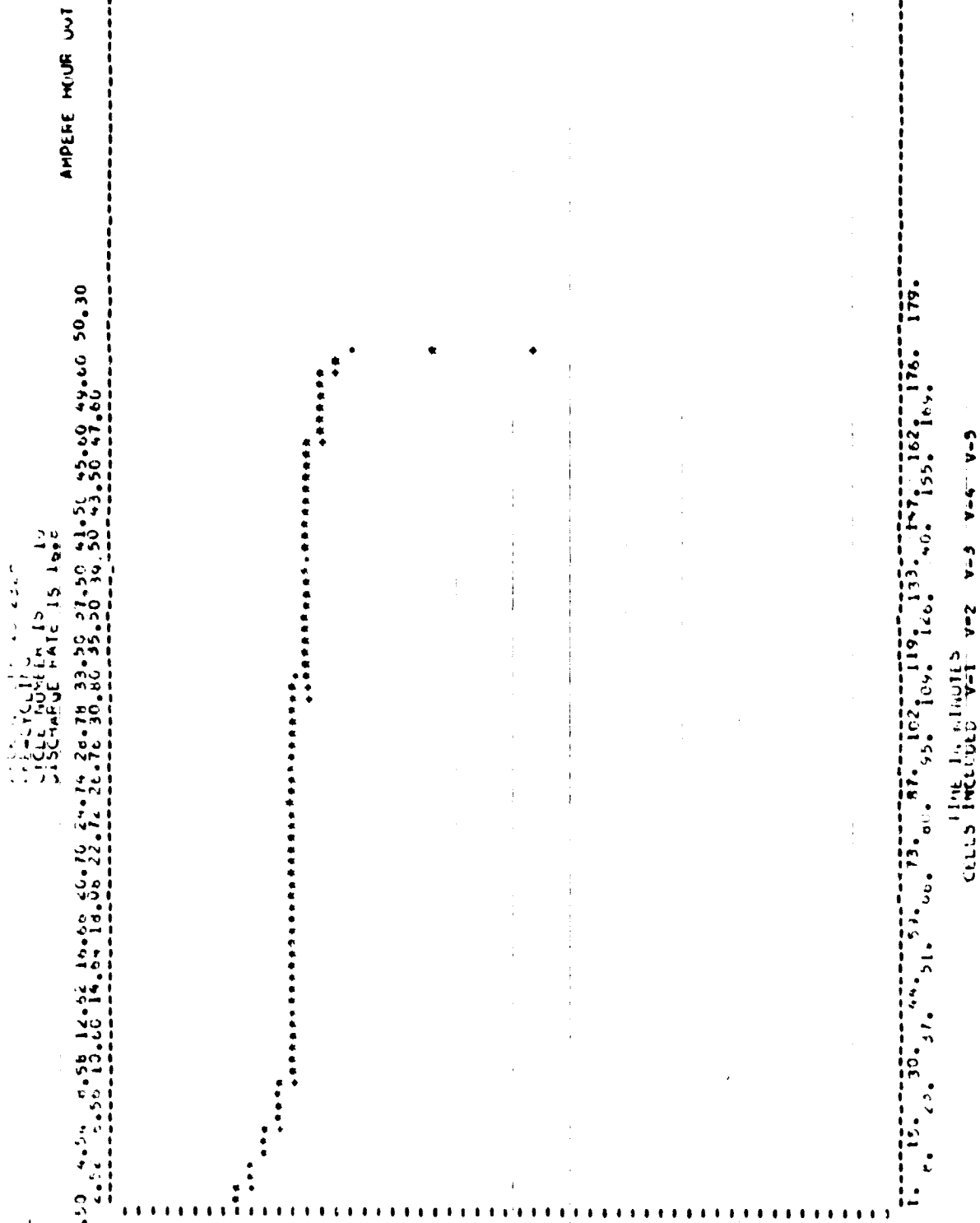


FIGURE 354

* HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 232A
 RECORD PRIOR TO SHADOW 02
 CYCLE NUMBER IS 50
 DISCHARGE RATE IS 16-0hm Resistor

WQEC/C 81-120A

AMPERE HOUR OUT

01. 6.04 13.06 18.01 24.07 30.03 34.03 42.15 48.03 54.03 59.43 60.62
 3.00 9.33 15.07 21.07 27.03 33.03 39.03 45.03 51.03 57.01 60.39

C 1.57
 A 1.51
 F 1.48
 A 1.42
 C 1.37
 I 1.31
 I 1.25
 Y 1.19
 C 1.13
 E 1.07
 L 1.01
 L 0.95
 V 0.89
 C 0.83
 L 0.77
 T 0.71
 A 0.65
 C 0.59
 S 0.53
 A 0.47
 L 0.41
 E 0.35

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0. 7. 14. 22. 29. 37. 44. 52. 60. 68. 75. 83. 91. 100. 108. 124. 140. 157. 167.
 168. 175. 182. 190. 198. 206. 214. 222. 230. 238. 246. 254. 262. 270. 278. 286. 294. 302. 310. 318. 326. 334. 342. 350. 358. 366. 374. 382. 390. 398. 406. 414. 422. 430. 438. 446. 454. 462. 470. 478. 486. 494. 502. 510. 518. 526. 534. 542. 550. 558. 566. 574. 582. 590. 598. 606. 614. 622. 630. 638. 646. 654. 662. 670. 678. 686. 694. 702. 710. 718. 726. 734. 742. 750. 758. 766. 774. 782. 790. 798. 806. 814. 822. 830. 838. 846. 854. 862. 870. 878. 886. 894. 902. 910. 918. 926. 934. 942. 950. 958. 966. 974. 982. 990. 998. 1006. 1014. 1022. 1030. 1038. 1046. 1054. 1062. 1070. 1078. 1086. 1094. 1102. 1110. 1118. 1126. 1134. 1142. 1150. 1158. 1166. 1174. 1182. 1190. 1198. 1206. 1214. 1222. 1230. 1238. 1246. 1254. 1262. 1270. 1278. 1286. 1294. 1302. 1310. 1318. 1326. 1334. 1342. 1350. 1358. 1366. 1374. 1382. 1390. 1398. 1406. 1414. 1422. 1430. 1438. 1446. 1454. 1462. 1470. 1478. 1486. 1494. 1502. 1510. 1518. 1526. 1534. 1542. 1550. 1558. 1566. 1574. 1582. 1590. 1598. 1606. 1614. 1622. 1630. 1638. 1646. 1654. 1662. 1670. 1678. 1686. 1694. 1702. 1710. 1718. 1726. 1734. 1742. 1750. 1758. 1766. 1774. 1782. 1790. 1798. 1806. 1814. 1822. 1830. 1838. 1846. 1854. 1862. 1870. 1878. 1886. 1894. 1902. 1910. 1918. 1926. 1934. 1942. 1950. 1958. 1966. 1974. 1982. 1990. 1998. 2006. 2014. 2022. 2030. 2038. 2046. 2054. 2062. 2070. 2078. 2086. 2094. 2102. 2110. 2118. 2126. 2134. 2142. 2150. 2158. 2166. 2174. 2182. 2190. 2198. 2206. 2214. 2222. 2230. 2238. 2246. 2254. 2262. 2270. 2278. 2286. 2294. 2302. 2310. 2318. 2326. 2334. 2342. 2350. 2358. 2366. 2374. 2382. 2390. 2398. 2406. 2414. 2422. 2430. 2438. 2446. 2454. 2462. 2470. 2478. 2486. 2494. 2502. 2510. 2518. 2526. 2534. 2542. 2550. 2558. 2566. 2574. 2582. 2590. 2598. 2606. 2614. 2622. 2630. 2638. 2646. 2654. 2662. 2670. 2678. 2686. 2694. 2702. 2710. 2718. 2726. 2734. 2742. 2750. 2758. 2766. 2774. 2782. 2790. 2798. 2806. 2814. 2822. 2830. 2838. 2846. 2854. 2862. 2870. 2878. 2886. 2894. 2902. 2910. 2918. 2926. 2934. 2942. 2950. 2958. 2966. 2974. 2982. 2990. 2998. 3006. 3014. 3022. 3030. 3038. 3046. 3054. 3062. 3070. 3078. 3086. 3094. 3102. 3110. 3118. 3126. 3134. 3142. 3150. 3158. 3166. 3174. 3182. 3190. 3198. 3206. 3214. 3222. 3230. 3238. 3246. 3254. 3262. 3270. 3278. 3286. 3294. 3302. 3310. 3318. 3326. 3334. 3342. 3350. 3358. 3366. 3374. 3382. 3390. 3398. 3406. 3414. 3422. 3430. 3438. 3446. 3454. 3462. 3470. 3478. 3486. 3494. 3502. 3510. 3518. 3526. 3534. 3542. 3550. 3558. 3566. 3574. 3582. 3590. 3598. 3606. 3614. 3622. 3630. 3638. 3646. 3654. 3662. 3670. 3678. 3686. 3694. 3702. 3710. 3718. 3726. 3734. 3742. 3750. 3758. 3766. 3774. 3782. 3790. 3798. 3806. 3814. 3822. 3830. 3838. 3846. 3854. 3862. 3870. 3878. 3886. 3894. 3902. 3910. 3918. 3926. 3934. 3942. 3950. 3958. 3966. 3974. 3982. 3990. 3998. 4006. 4014. 4022. 4030. 4038. 4046. 4054. 4062. 4070. 4078. 4086. 4094. 4102. 4110. 4118. 4126. 4134. 4142. 4150. 4158. 4166. 4174. 4182. 4190. 4198. 4206. 4214. 4222. 4230. 4238. 4246. 4254. 4262. 4270. 4278. 4286. 4294. 4302. 4310. 4318. 4326. 4334. 4342. 4350. 4358. 4366. 4374. 4382. 4390. 4398. 4406. 4414. 4422. 4430. 4438. 4446. 4454. 4462. 4470. 4478. 4486. 4494. 4502. 4510. 4518. 4526. 4534. 4542. 4550. 4558. 4566. 4574. 4582. 4590. 4598. 4606. 4614. 4622. 4630. 4638. 4646. 4654. 4662. 4670. 4678. 4686. 4694. 4702. 4710. 4718. 4726. 4734. 4742. 4750. 4758. 4766. 4774. 4782. 4790. 4798. 4806. 4814. 4822. 4830. 4838. 4846. 4854. 4862. 4870. 4878. 4886. 4894. 4902. 4910. 4918. 4926. 4934. 4942. 4950. 4958. 4966. 4974. 4982. 4990. 4998. 5006. 5014. 5022. 5030. 5038. 5046. 5054. 5062. 5070. 5078. 5086. 5094. 5102. 5110. 5118. 5126. 5134. 5142. 5150. 5158. 5166. 5174. 5182. 5190. 5198. 5206. 5214. 5222. 5230. 5238. 5246. 5254. 5262. 5270. 5278. 5286. 5294. 5302. 5310. 5318. 5326. 5334. 5342. 5350. 5358. 5366. 5374. 5382. 5390. 5398. 5406. 5414. 5422. 5430. 5438. 5446. 5454. 5462. 5470. 5478. 5486. 5494. 5502. 5510. 5518. 5526. 5534. 5542. 5550. 5558. 5566. 5574. 5582. 5590. 5598. 5606. 5614. 5622. 5630. 5638. 5646. 5654. 5662. 5670. 5678. 5686. 5694. 5702. 5710. 5718. 5726. 5734. 5742. 5750. 5758. 5766. 5774. 5782. 5790. 5798. 5806. 5814. 5822. 5830. 5838. 5846. 5854. 5862. 5870. 5878. 5886. 5894. 5902. 5910. 5918. 5926. 5934. 5942. 5950. 5958. 5966. 5974. 5982. 5990. 5998. 6006. 6014. 6022. 6030. 6038. 6046. 6054. 6062. 6070. 6078. 6086. 6094. 6102. 6110. 6118. 6126. 6134. 6142. 6150. 6158. 6166. 6174. 6182. 6190. 6198. 6206. 6214. 6222. 6230. 6238. 6246. 6254. 6262. 6270. 6278. 6286. 6294. 6302. 6310. 6318. 6326. 6334. 6342. 6350. 6358. 6366. 6374. 6382. 6390. 6398. 6406. 6414. 6422. 6430. 6438. 6446. 6454. 6462. 6470. 6478. 6486. 6494. 6502. 6510. 6518. 6526. 6534. 6542. 6550. 6558. 6566. 6574. 6582. 6590. 6598. 6606. 6614. 6622. 6630. 6638. 6646. 6654. 6662. 6670. 6678. 6686. 6694. 6702. 6710. 6718. 6726. 6734. 6742. 6750. 6758. 6766. 6774. 6782. 6790. 6798. 6806. 6814. 6822. 6830. 6838. 6846. 6854. 6862. 6870. 6878. 6886. 6894. 6902. 6910. 6918. 6926. 6934. 6942. 6950. 6958. 6966. 6974. 6982. 6990. 6998. 7006. 7014. 7022. 7030. 7038. 7046. 7054. 7062. 7070. 7078. 7086. 7094. 7102. 7110. 7118. 7126. 7134. 7142. 7150. 7158. 7166. 7174. 7182. 7190. 7198. 7206. 7214. 7222. 7230. 7238. 7246. 7254. 7262. 7270. 7278. 7286. 7294. 7302. 7310. 7318. 7326. 7334. 7342. 7350. 7358. 7366. 7374. 7382. 7390. 7398. 7406. 7414. 7422. 7430. 7438. 7446. 7454. 7462. 7470. 7478. 7486. 7494. 7502. 7510. 7518. 7526. 7534. 7542. 7550. 7558. 7566. 7574. 7582. 7590. 7598. 7606. 7614. 7622. 7630. 7638. 7646. 7654. 7662. 7670. 7678. 7686. 7694. 7702. 7710. 7718. 7726. 7734. 7742. 7750. 7758. 7766. 7774. 7782. 7790. 7798. 7806. 7814. 7822. 7830. 7838. 7846. 7854. 7862. 7870. 7878. 7886. 7894. 7902. 7910. 7918. 7926. 7934. 7942. 7950. 7958. 7966. 7974. 7982. 7990. 7998. 8006. 8014. 8022. 8030. 8038. 8046. 8054. 8062. 8070. 8078. 8086. 8094. 8102. 8110. 8118. 8126. 8134. 8142. 8150. 8158. 8166. 8174. 8182. 8190. 8198. 8206. 8214. 8222. 8230. 8238. 8246. 8254. 8262. 8270. 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11950. 11958. 11966. 11974. 11982. 11990. 11998. 12006. 12014. 12022. 12030. 12038. 12046. 12054. 12062. 12070. 12078. 12086. 12094. 12102. 12110. 12118. 12126. 12134. 12142. 12150. 12158. 12166. 12174. 12182. 12190. 12198. 12206. 12214. 12222. 12230. 12238. 12246. 12254. 12262. 12270. 12278. 12286. 12294. 12302. 12310. 12318. 12326. 12334. 12342. 12350. 12358. 12366. 12374. 12382. 12390. 12398. 12406. 12414. 12422. 12430. 12438. 12446. 12454. 12462. 12470. 12478. 12486. 12494. 12502. 12510. 12518. 12526. 12534. 12542. 12550. 12558. 12566. 12574. 12582. 12590. 12598. 12606. 12614. 12622. 12630. 12638. 12646. 12654. 12662. 12670. 12678. 12686. 12694. 12702. 12710. 12718. 12726. 12734. 12742. 12750. 12758. 12766. 12774. 12782. 12790. 12798. 12806. 12814. 12822. 12830. 12838. 12846. 12854. 12862. 12870. 12878. 12886. 12894. 12902. 12910. 12918. 12926. 12934. 12942. 12950. 12958. 12966. 12974. 12982. 12990. 12998. 13006. 13014. 13022. 13030. 13038. 13046. 13054. 13062. 13070. 13078. 13086. 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14238. 14246. 14254. 14262. 14270. 14278. 14286. 14294. 14302. 14310. 14318. 14326. 14334. 14342. 14350. 14358. 14366. 14374. 14382. 14390. 14398. 14406. 14414. 14422. 14430. 14438. 14446. 14454. 14462. 14470. 14478. 14486. 14494. 14502. 14510. 14518. 14526. 14534. 14542. 14550. 14558. 14566. 14574. 14582. 14590. 14598. 14606. 14614. 14622. 14630. 14638. 14646. 14654. 14662. 14670. 14678. 14686. 14694. 14702. 14710. 14718. 14726. 14734. 14742. 14750. 14758. 14766. 14774. 14782. 14790. 14798. 14806. 14814. 14822. 14830. 14838. 14846. 14854. 14862. 14870. 1487

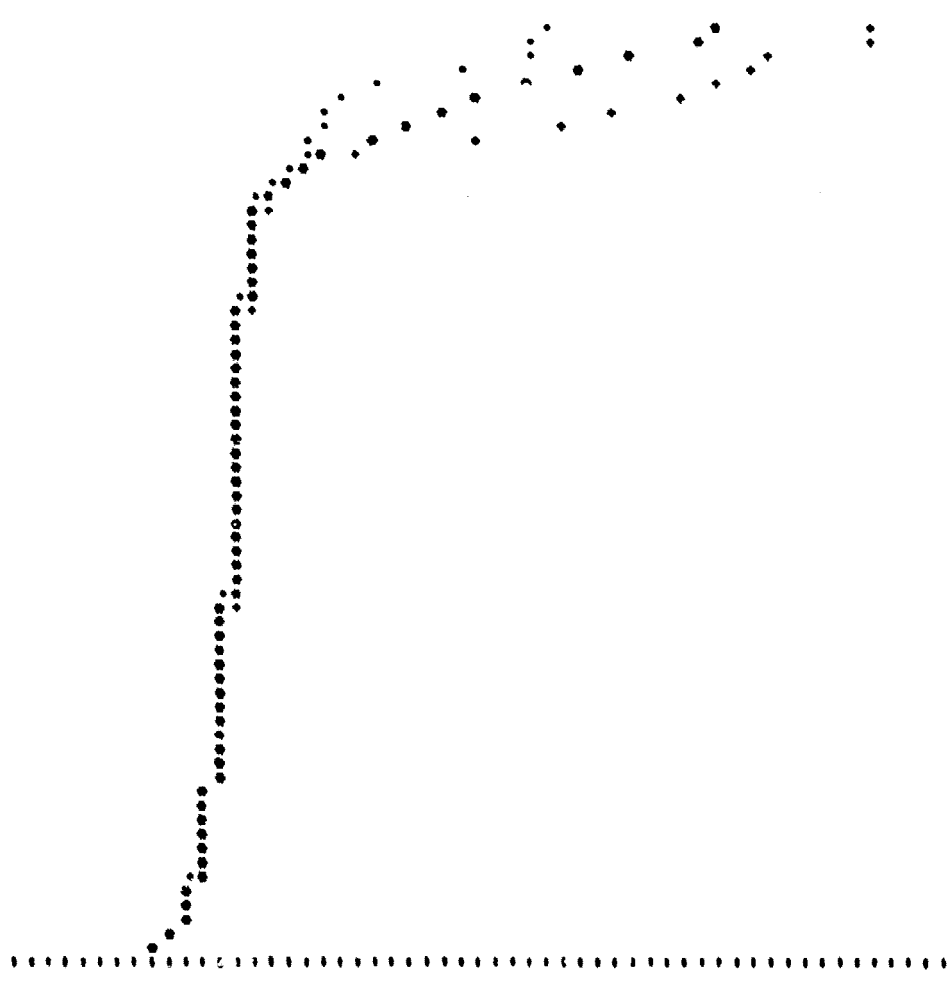
• AVERAGE

DISCHARGE RATE IS 26-Over Resistor

AMPERE HOUR OUT

1.00 7.20 11.00 13.00 25.50 28.12 37.08 43.22 49.14 55.02 59.04 61.30
4.21 10.25 16.01 22.00 28.12 34.32 40.14 46.08 52.02 57.67 60.51

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2. 17. 32. 47. 53. 79. 79. 87. 103. 119. 127. 143. 155. 167.
4. 21. 24. 39. 55. 71. 87. 103. 119. 135. 151. 162.

TIME IN HOURS
CELLS INCLUDED 1-1 V-2 V-3 V-4 V-5

FIGURE 356

AVERAGE

DISCHARGE RATE IS 16-Ohm Resistor

AMPERE HOUR OUT

0. 6. 12. 18. 24. 30. 36. 42. 48. 54. 60. 66. 72. 78. 84. 90. 96. 102. 108. 114. 120. 126. 132. 138. 144. 150. 156. 162. 168. 174. 180. 186. 192. 198. 204. 210. 216. 222. 228. 234. 240. 246. 252. 258. 264. 270. 276. 282. 288. 294. 300. 306. 312. 318. 324. 330. 336. 342. 348. 354. 360. 366. 372. 378. 384. 390. 396. 402. 408. 414. 420. 426. 432. 438. 444. 450. 456. 462. 468. 474. 480. 486. 492. 498. 504. 510. 516. 522. 528. 534. 540. 546. 552. 558. 564. 570. 576. 582. 588. 594. 600. 606. 612. 618. 624. 630. 636. 642. 648. 654. 660. 666. 672. 678. 684. 690. 696. 702. 708. 714. 720. 726. 732. 738. 744. 750. 756. 762. 768. 774. 780. 786. 792. 798. 804. 810. 816. 822. 828. 834. 840. 846. 852. 858. 864. 870. 876. 882. 888. 894. 900. 906. 912. 918. 924. 930. 936. 942. 948. 954. 960. 966. 972. 978. 984. 990. 996. 1002. 1008. 1014. 1020. 1026. 1032. 1038. 1044. 1050. 1056. 1062. 1068. 1074. 1080. 1086. 1092. 1098. 1104. 1110. 1116. 1122. 1128. 1134. 1140. 1146. 1152. 1158. 1164. 1170. 1176. 1182. 1188. 1194. 1200. 1206. 1212. 1218. 1224. 1230. 1236. 1242. 1248. 1254. 1260. 1266. 1272. 1278. 1284. 1290. 1296. 1302. 1308. 1314. 1320. 1326. 1332. 1338. 1344. 1350. 1356. 1362. 1368. 1374. 1380. 1386. 1392. 1398. 1404. 1410. 1416. 1422. 1428. 1434. 1440. 1446. 1452. 1458. 1464. 1470. 1476. 1482. 1488. 1494. 1500. 1506. 1512. 1518. 1524. 1530. 1536. 1542. 1548. 1554. 1560. 1566. 1572. 1578. 1584. 1590. 1596. 1602. 1608. 1614. 1620. 1626. 1632. 1638. 1644. 1650. 1656. 1662. 1668. 1674. 1680. 1686. 1692. 1698. 1704. 1710. 1716. 1722. 1728. 1734. 1740. 1746. 1752. 1758. 1764. 1770. 1776. 1782. 1788. 1794. 1800. 1806. 1812. 1818. 1824. 1830. 1836. 1842. 1848. 1854. 1860. 1866. 1872. 1878. 1884. 1890. 1896. 1902. 1908. 1914. 1920. 1926. 1932. 1938. 1944. 1950. 1956. 1962. 1968. 1974. 1980. 1986. 1992. 1998. 2004. 2010. 2016. 2022. 2028. 2034. 2040. 2046. 2052. 2058. 2064. 2070. 2076. 2082. 2088. 2094. 2100. 2106. 2112. 2118. 2124. 2130. 2136. 2142. 2148. 2154. 2160. 2166. 2172. 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5166. 5172. 5178. 5184. 5190. 5196. 5202. 5208. 5214. 5220. 5226. 5232. 5238. 5244. 5250. 5256. 5262. 5268. 5274. 5280. 5286. 5292. 5298. 5304. 5310. 5316. 5322. 5328. 5334. 5340. 5346. 5352. 5358. 5364. 5370. 5376. 5382. 5388. 5394. 5400. 5406. 5412. 5418. 5424. 5430. 5436. 5442. 5448. 5454. 5460. 5466. 5472. 5478. 5484. 5490. 5496. 5502. 5508. 5514. 5520. 5526. 5532. 5538. 5544. 5550. 5556. 5562. 5568. 5574. 5580. 5586. 5592. 5598. 5604. 5610. 5616. 5622. 5628. 5634. 5640. 5646. 5652. 5658. 5664. 5670. 5676. 5682. 5688. 5694. 5700. 5706. 5712. 5718. 5724. 5730. 5736. 5742. 5748. 5754. 5760. 5766. 5772. 5778. 5784. 5790. 5796. 5802. 5808. 5814. 5820. 5826. 5832. 5838. 5844. 5850. 5856. 5862. 5868. 5874. 5880. 5886. 5892. 5898. 5904. 5910. 5916. 5922. 5928. 5934. 5940. 5946. 5952. 5958. 5964. 5970. 5976. 5982. 5988. 5994. 6000. 6006. 6012. 6018. 6024. 6030. 6036. 6042. 6048. 6054. 6060. 6066. 6072. 6078. 6084. 6090. 6096. 6102. 6108. 6114. 6120. 6126. 6132. 6138. 6144. 6150. 6156. 6162. 6168. 6174. 6180. 6186. 6192. 6198. 6204. 6210. 6216. 6222. 6228. 6234. 6240. 6246. 6252. 6258. 6264. 6270. 6276. 6282. 6288. 6294. 6300. 6306. 6312. 6318. 6324. 6330. 6336. 6342. 6348. 6354. 6360. 6366. 6372. 6378. 6384. 6390. 6396. 6402. 6408. 6414. 6420. 6426. 6432. 6438. 6444. 6450. 6456. 6462. 6468. 6474. 6480. 6486. 6492. 6498. 6504. 6510. 6516. 6522. 6528. 6534. 6540. 6546. 6552. 6558. 6564. 6570. 6576. 6582. 6588. 6594. 6600. 6606. 6612. 6618. 6624. 6630. 6636. 6642. 6648. 6654. 6660. 6666. 6672. 6678. 6684. 6690. 6696. 6702. 6708. 6714. 6720. 6726. 6732. 6738. 6744. 6750. 6756. 6762. 6768. 6774. 6780. 6786. 6792. 6798. 6804. 6810. 6816. 6822. 6828. 6834. 6840. 6846. 6852. 6858. 6864. 6870. 6876. 6882. 6888. 6894. 6900. 6906. 6912. 6918. 6924. 6930. 6936. 6942. 6948. 6954. 6960. 6966. 6972. 6978. 6984. 6990. 6996. 7002. 7008. 7014. 7020. 7026. 7032. 7038. 7044. 7050. 7056. 7062. 7068. 7074. 7080. 7086. 7092. 7098. 7104. 7110. 7116. 7122. 7128. 7134. 7140. 7146. 7152. 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10986. 10992. 10998. 11004. 11010. 11016. 11022. 11028. 11034. 11040. 11046. 11052. 11058. 11064. 11070. 11076. 11082. 11088. 11094. 11100. 11106. 11112. 11118. 11124. 11130. 11136. 11142. 11148. 11154. 11160. 11166. 11172. 11178. 11184. 11190. 11196. 11202. 11208. 11214. 11220. 11226. 11232. 11238. 11244. 11250. 11256. 11262. 11268. 11274. 11280. 11286. 11292. 11298. 11304. 11310. 11316. 11322. 11328. 11334. 11340. 11346. 11352. 11358. 11364. 11370. 11376. 11382. 11388. 11394. 11400. 11406. 11412. 11418. 11424. 11430. 11436. 11442. 11448. 11454. 11460. 11466. 11472. 11478. 11484. 11490. 11496. 11502. 11508. 11514. 11520. 11526. 11532. 11538. 11544. 11550. 11556. 11562. 11568. 11574. 11580. 11586. 11592. 11598. 11604. 11610. 11616. 11622. 11628. 11634. 11640. 11646. 11652. 11658. 11664. 11670. 11676. 11682. 11688. 11694. 11700. 11706. 11712. 11718. 11724. 11730. 11736. 11742. 11748. 11754. 11760. 11766. 11772. 11778. 11784. 11790. 11796. 11802. 11808. 11814. 11820. 11826. 11832. 11838. 11844. 11850. 11856. 11862. 11868. 11874. 11880. 11886. 11892. 11898. 11904. 11910. 11916. 11922. 11928. 11934. 11940. 11946. 11952. 11958. 11964. 11970. 11976. 11982. 11988. 11994. 12000. 12006. 12012. 12018. 12024. 12030. 12036. 12042. 12048. 12054. 12060. 12066. 12072. 12078. 1

NEWTON CELL
+ LOW CELL
+ AVERAGE

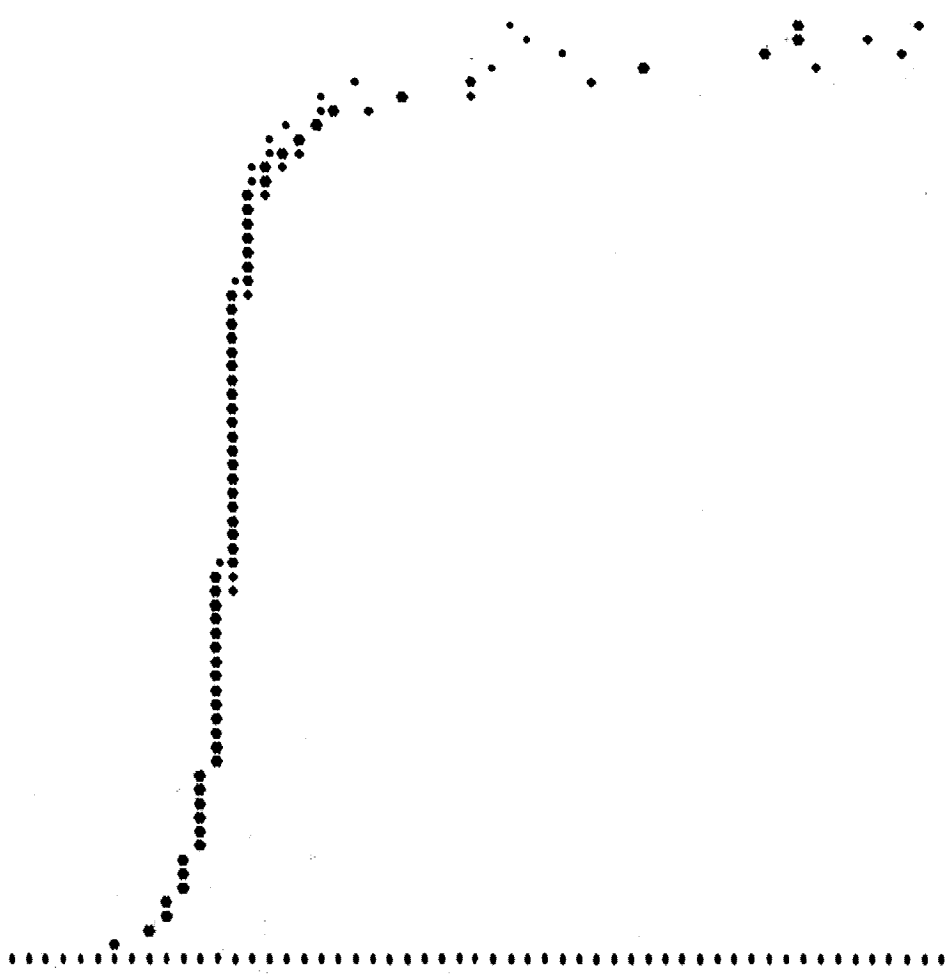
PACK NUMBER IS 232A
SECOND PRIOR TO SHADON 06
CYCLE NUMBER IS 823
DISCHARGE RATE IS 16-7mm Resistor

WQC/C 81-120A

AMPERE HOUR OUT

0. 6. 01 11. 07 18. 05 24. 09 30. 03 35. 05 41. 07 48. 09 54. 21 60. 11 65. 33
1. 08 1. 01 14. 07 20. 04 27. 02 32. 97 38. 09 45. 21 50. 97 56. 93 62. 99

0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.



0. 14. 29. 44. 59. 75. 91. 107. 124. 140. 157. 173. 189. 206. 222. 239. 255. 272. 288. 305. 321. 338. 354. 371. 387. 404. 420. 437. 453. 470. 486. 503. 519. 536. 552. 569. 585. 602. 618. 635. 651. 668. 684. 701. 717. 734. 750. 767. 783. 800. 816. 833. 849. 866. 882. 899. 915. 932. 948. 965. 981. 998. 1014. 1031. 1047. 1064. 1080. 1097. 1113. 1130. 1146. 1163. 1179. 1195. 1212. 1228. 1245. 1261. 1278. 1294. 1311. 1327. 1344. 1360. 1377. 1393. 1410. 1426. 1443. 1459. 1476. 1492. 1509. 1525. 1542. 1558. 1575. 1591. 1608. 1624. 1641. 1657. 1674. 1690. 1707. 1723. 1740. 1756. 1773. 1789. 1806. 1822. 1839. 1855. 1872. 1888. 1905. 1921. 1938. 1954. 1971. 1987. 2004. 2020. 2037. 2053. 2070. 2086. 2103. 2119. 2136. 2152. 2169. 2185. 2202. 2218. 2235. 2251. 2268. 2284. 2301. 2317. 2334. 2350. 2367. 2383. 2400. 2416. 2433. 2449. 2466. 2482. 2499. 2515. 2532. 2548. 2565. 2581. 2598. 2614. 2631. 2647. 2664. 2680. 2697. 2713. 2730. 2746. 2763. 2779. 2796. 2812. 2829. 2845. 2862. 2878. 2895. 2911. 2928. 2944. 2961. 2977. 2994. 3010. 3027. 3043. 3060. 3076. 3093. 3109. 3126. 3142. 3159. 3175. 3192. 3208. 3225. 3241. 3258. 3274. 3291. 3307. 3324. 3340. 3357. 3373. 3390. 3406. 3423. 3439. 3456. 3472. 3489. 3505. 3522. 3538. 3555. 3571. 3588. 3604. 3621. 3637. 3654. 3670. 3687. 3703. 3720. 3736. 3753. 3769. 3786. 3802. 3819. 3835. 3852. 3868. 3885. 3901. 3918. 3934. 3951. 3967. 3984. 4000. 4017. 4033. 4050. 4066. 4083. 4100. 4116. 4133. 4149. 4166. 4182. 4199. 4215. 4232. 4248. 4265. 4281. 4298. 4314. 4331. 4347. 4364. 4380. 4397. 4413. 4430. 4446. 4463. 4479. 4496. 4512. 4529. 4545. 4562. 4578. 4595. 4611. 4628. 4644. 4661. 4677. 4694. 4710. 4727. 4743. 4760. 4776. 4793. 4809. 4826. 4842. 4859. 4875. 4892. 4908. 4925. 4941. 4958. 4974. 4991. 5007. 5024. 5040. 5057. 5073. 5090. 5106. 5123. 5139. 5156. 5172. 5189. 5205. 5222. 5238. 5255. 5271. 5288. 5304. 5321. 5337. 5354. 5370. 5387. 5403. 5420. 5436. 5453. 5469. 5486. 5502. 5519. 5535. 5552. 5568. 5585. 5601. 5618. 5634. 5651. 5667. 5684. 5700. 5717. 5733. 5750. 5766. 5783. 5800. 5816. 5833. 5849. 5866. 5882. 5899. 5915. 5932. 5948. 5965. 5981. 6000. 6016. 6032. 6049. 6065. 6082. 6098. 6115. 6131. 6148. 6164. 6181. 6197. 6214. 6230. 6247. 6263. 6280. 6296. 6313. 6329. 6346. 6362. 6379. 6395. 6412. 6428. 6445. 6461. 6478. 6494. 6511. 6527. 6544. 6560. 6577. 6593. 6610. 6626. 6643. 6659. 6676. 6692. 6709. 6725. 6742. 6758. 6775. 6791. 6808. 6824. 6841. 6857. 6874. 6890. 6907. 6923. 6940. 6956. 6973. 6989. 7006. 7022. 7039. 7055. 7072. 7088. 7105. 7121. 7138. 7154. 7171. 7187. 7204. 7220. 7237. 7253. 7270. 7286. 7303. 7319. 7336. 7352. 7369. 7385. 7402. 7418. 7435. 7451. 7468. 7484. 7501. 7517. 7534. 7550. 7567. 7583. 7600. 7616. 7633. 7649. 7666. 7682. 7699. 7715. 7732. 7748. 7765. 7781. 7798. 7814. 7831. 7847. 7864. 7880. 7897. 7913. 7930. 7946. 7963. 7979. 7996. 8012. 8029. 8045. 8062. 8078. 8095. 8111. 8128. 8144. 8161. 8177. 8194. 8210. 8227. 8243. 8260. 8276. 8293. 8309. 8326. 8342. 8359. 8375. 8392. 8408. 8425. 8441. 8458. 8474. 8491. 8507. 8524. 8540. 8557. 8573. 8590. 8606. 8623. 8639. 8656. 8672. 8689. 8705. 8722. 8738. 8755. 8771. 8788. 8804. 8821. 8837. 8854. 8870. 8887. 8903. 8920. 8936. 8953. 8969. 8986. 9002. 9019. 9035. 9052. 9068. 9085. 9101. 9118. 9134. 9151. 9167. 9184. 9200. 9217. 9233. 9250. 9266. 9283. 9299. 9316. 9332. 9349. 9365. 9382. 9398. 9415. 9431. 9448. 9464. 9481. 9497. 9514. 9530. 9547. 9563. 9580. 9596. 9613. 9629. 9646. 9662. 9679. 9695. 9712. 9728. 9745. 9761. 9778. 9794. 9811. 9827. 9844. 9860. 9877. 9893. 9910. 9926. 9943. 9959. 9976. 9992. 10000.

TIME IN HOURS
CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 359

ORIGINAL PAGE IS
OF POOR QUALITY

DEPTH DISCHARGE 50
 TEMPERATURE 00
 AMPERE RATE 50
 GENERAL ELECTRIC
 PROJECT 170953
 SERIAL 0102103-04-05

SYNCHRONOUS ORBIT SHADOW PLOT

KEY
 HIGH END DISCHARGE VOLTAGE
 LOW END DISCHARGE VOLTAGE
 LOC END DISCHARGE VOLTAGE
 ENC-170953
 ENC-170953

PACK = 232A

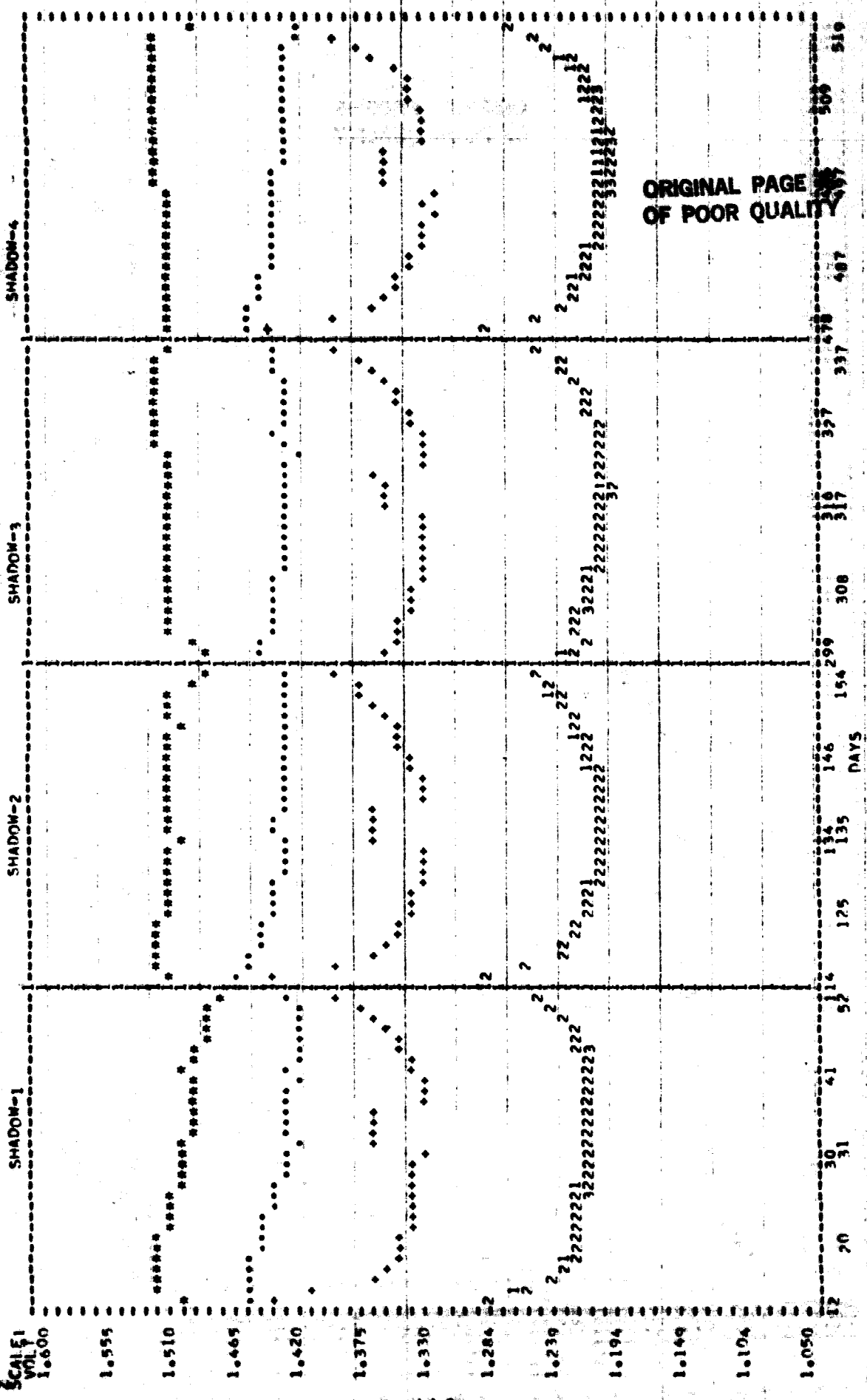


FIGURE 360

KEY HIGH END DISCHARGE VOLTAGE
1 AVE END DISCHARGE VOLTAGE
2 LOW END DISCHARGE VOLTAGE
LOC-2.67 AMP
LOC-1 INCH
LOC-1 IN-RUSH

SYNCHRONOUS ORBIT SHADOW PLOT

| | |
|------------------|----|
| DEPTH DISCHARGE | 50 |
| TEMPERATURE | 00 |
| AMPERE RATE | 00 |
| GENERAL ELECTRIC | |

PROJECT TORSS
SERIAL 01,02,03,04,05

PACK = 232A

CALL:

5-NOV-63

9-4007MS

SHADOW-

\$4400V-

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 12 20 30 31 41 52 114 125 134 135 146 154 299 308 316 327 337 478 487 498 509 519

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 50
 TEMPERATURE 00
 ALTITUDE 40
 ACQUIRE DATE 0210310405
 SERIAL 0000000000
 PROJECT : YORSS

PACK = 232A

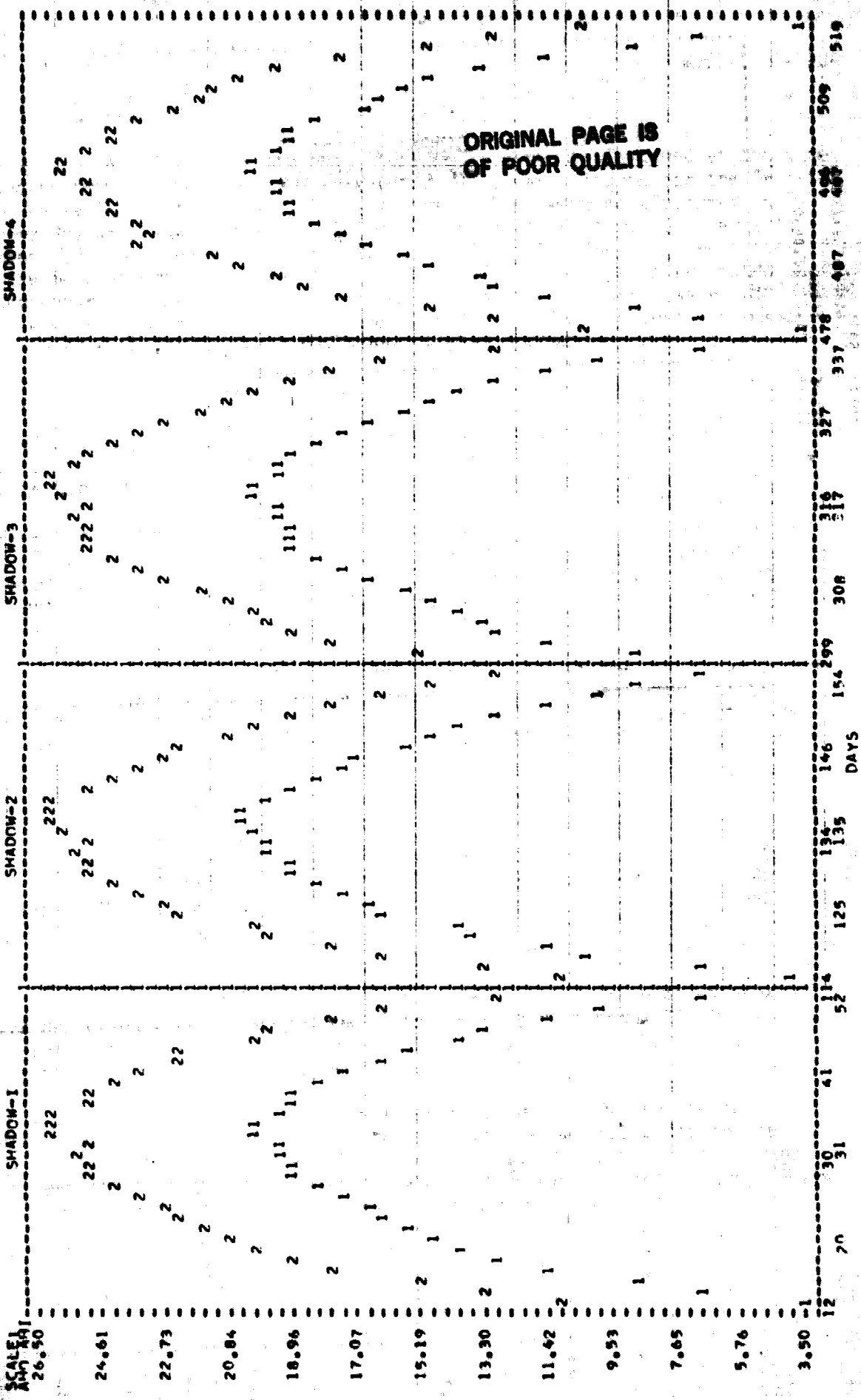


FIGURE 362

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SYNCHRONOUS ORBIT SHADOW PLOT

PACM - 232A

DEPTH DISCHARGE 50
TEMPERATURE 00
AMPERE RATE 40
SERIAL 01 02 03 04 05
PROJECT GENERAL ELECTRIC
TORRES

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OF POOR QUALITY**

[illegible]

2. Pack 2328, 5-cells

a. Cell information: These cells were manufactured at the same time and from the same materials as Lot 2 cells manufactured for the Tracking Data Relay Satellite System (TDRSS) program. They were manufactured in accordance with TRW Part/Material Control Document "Battery Cells 40 ah", Number 8E011 and General Electric MCD 232A2222AA-80. The cells were identified by the manufacturer's catalog number 42B040AB03. These cells are rated at 40.0 ampere-hours, contain double ceramic seals, and cells 4 and 5 were fitted with pressure transducers prior to testing. Initial evaluation test results are contained in NAVPNSUPPCEN Crane Report WQEC/C 80-194.

b. Parameters:

| | | | |
|------------------------|----|--------------------------|-------|
| Depth of Discharge (%) | 50 | Discharge Current (amps) | 16.67 |
| Charge Control | CC | Temperature (°C) | 15 |
| Charge Current (amps)* | | Float Current (amps) | .27 |

*--In-rush current, for 10 minutes following discharge, is 21 amps for days 20, 21, 22, 23, and 24; and 12 amps for the other days. The current is then reduced to 2.67 amps until the percent recharge is 110 at which time the current is reduced to .27 amps. The pack receives a 6-amp charge for 10 minutes the day prior to and following each shadow period.

c. Capacity Check/Reconditioning: (Discharge to .75 volts any cell prior to every fourth shadow. Reconditioning is performed, prior to the other shadows, by placing a 16-ohm resistor across the pack until the pack voltage is .40 volts. This is also done following the capacity check.)

| | Cell
<u>1</u> | Cell
<u>2</u> | Cell
<u>3</u> | Cell
<u>4</u> | Cell
<u>5</u> | ah |
|-------------------------|------------------|------------------|------------------|------------------|------------------|-------|
| Precycling (Figure 364) | -.120 | -.249 | .806 | 1.153 | 1.129 | 47.06 |
| Recond 2 (Figure 365) | -.023 | -.017 | -.052 | -.057 | .548 | 63.41 |
| Recond 3 (Figure 366) | -.107 | -.049 | -.031 | -.074 | .668 | 64.74 |

d. Test results during the Shadow Periods: (Figures 367 and 368)

(1) End of Discharge Voltages: The average mid-shadow voltages have decreased from 1.208 (shadow 1) to 1.194 volts (shadow 3) with a 2 mv difference between the high (3,5) and low (2) cells the last shadow. The largest decrease was from shadow 1 to 2 which was 8 mv.

(2) Capacity/Reconditioning Effects: During the two reconditioning discharges, cell 5 has not gone below .500 volts and cell 2 has always been the first cell to reverse. Capacity to 1.00 v/c average has been constant at 59 ampere-hours with a time period of 47 hours. There is no reconditioning effect due to the daily discharges.

(3) End of Charge Voltages and Pressures:

(a) 2.67 ampere-rate---The average mid-shadow voltages have increased from 1.435 (shadow 1) to 1.442 volts (shadow 3) and the high to low cell difference has increased from 2 to 10 mv in which cells 4 and 2 were 1.448 and 1.438 volts respectively, the last shadow period. The pressures have also increased from 10 to 20 psia.

(b) .26 ampere-rate---The average mid-shadow voltages and pressures were 1.397 volts and 17 psia during shadow 3 which is an increase of 4 mv and 8 psia from the first shadow. Cell voltages have been within a 2 mv range for all three shadow periods.

(c) 6.0 ampere-rate---The average voltage prior to shadow 3 was 1.510 volts with a 1 mv difference between the high and low cells. Following shadow 3, the average voltage was 1.508 volts with cell 4 (1.517 volts) and cell 2 (1.501 volts) being the high and low cells.

WQEC/C 81-120A

e. Performance during Sun Periods: Pack has completed two sun periods as it began test with a shadow period. The pressures have not exceeded 13 psia during these periods. Following is a listing of the high, average, and low voltages at the start and the end of each sun period prior to reconditioning.

| <u>Voltages*</u> | 1 | | 2 | |
|------------------|---------------|---------------|---------------|-----------------|
| | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.391 (2,4,5) | 1.398 (2,4,5) | 1.399 (4,5) | 1.405 (1,2,3,4) |
| Average | 1.391 | 1.398 | 1.398 | 1.405 |
| Low | 1.390 (1,3) | 1.397 (1,3) | 1.398 (1,2,3) | 1.404 (5) |

*--() indicates which cells

PACK NUMBER IS 2320
CYCLING
CYCLE NUMBER IS 9
DISCHARGE RATE IS 16.6

AMPERE HOUR OUT

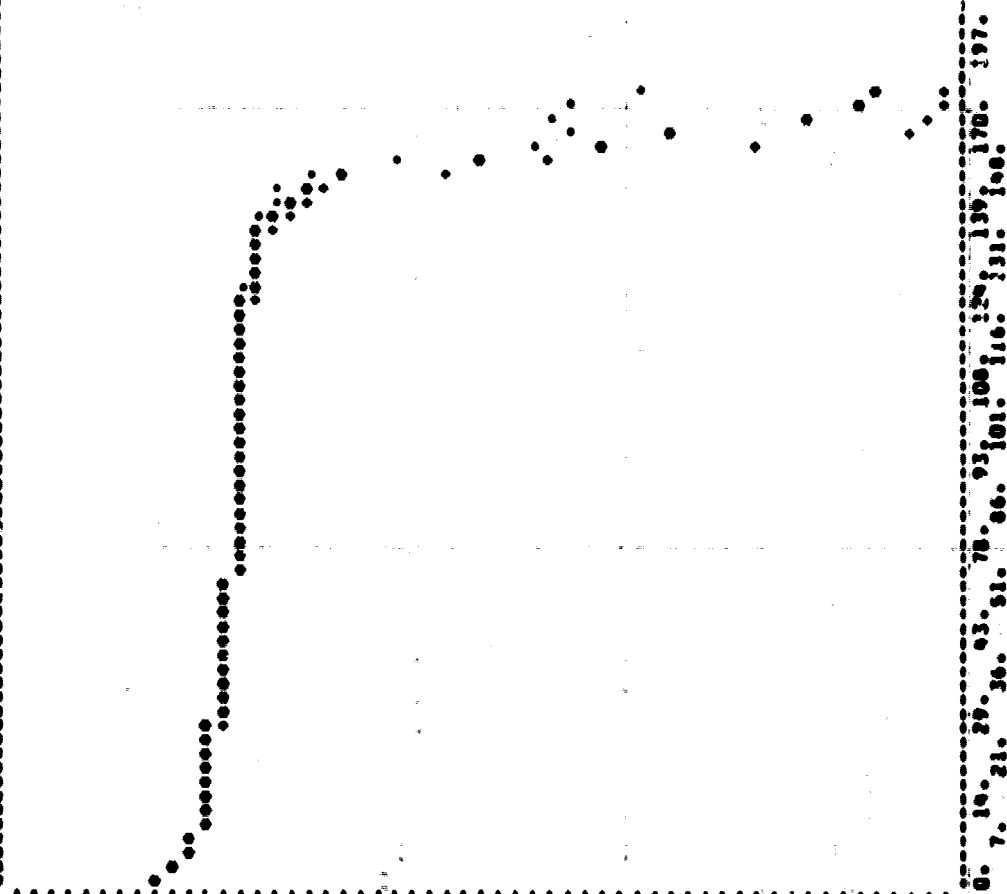
KEY
• HIGH CELL
• LOW CELL
• AVERAGE

1. 8. 16. 24. 30. 36. 42. 48. 54. 60. 66. 72. 78. 84. 90. 96. 102. 108. 114. 120. 126. 132. 138. 144. 150. 156. 162. 168. 174. 180. 186. 192. 198. 204. 210. 216. 222. 228. 234. 240. 246. 252. 258. 264. 270. 276. 282. 288. 294. 300. 306. 312. 318. 324. 330. 336. 342. 348. 354. 360. 366. 372. 378. 384. 390. 396. 402. 408. 414. 420. 426. 432. 438. 444. 450. 456. 462. 468. 474. 480. 486. 492. 498. 504. 510. 516. 522. 528. 534. 540. 546. 552. 558. 564. 570. 576. 582. 588. 594. 600. 606. 612. 618. 624. 630. 636. 642. 648. 654. 660. 666. 672. 678. 684. 690. 696. 702. 708. 714. 720. 726. 732. 738. 744. 750. 756. 762. 768. 774. 780. 786. 792. 798. 804. 810. 816. 822. 828. 834. 840. 846. 852. 858. 864. 870. 876. 882. 888. 894. 900. 906. 912. 918. 924. 930. 936. 942. 948. 954. 960. 966. 972. 978. 984. 990. 996. 1002. 1008. 1014. 1020. 1026. 1032. 1038. 1044. 1050. 1056. 1062. 1068. 1074. 1080. 1086. 1092. 1098. 1104. 1110. 1116. 1122. 1128. 1134. 1140. 1146. 1152. 1158. 1164. 1170. 1176. 1182. 1188. 1194. 1200. 1206. 1212. 1218. 1224. 1230. 1236. 1242. 1248. 1254. 1260. 1266. 1272. 1278. 1284. 1290. 1296. 1302. 1308. 1314. 1320. 1326. 1332. 1338. 1344. 1350. 1356. 1362. 1368. 1374. 1380. 1386. 1392. 1398. 1404. 1410. 1416. 1422. 1428. 1434. 1440. 1446. 1452. 1458. 1464. 1470. 1476. 1482. 1488. 1494. 1500. 1506. 1512. 1518. 1524. 1530. 1536. 1542. 1548. 1554. 1560. 1566. 1572. 1578. 1584. 1590. 1596. 1602. 1608. 1614. 1620. 1626. 1632. 1638. 1644. 1650. 1656. 1662. 1668. 1674. 1680. 1686. 1692. 1698. 1704. 1710. 1716. 1722. 1728. 1734. 1740. 1746. 1752. 1758. 1764. 1770. 1776. 1782. 1788. 1794. 1800. 1806. 1812. 1818. 1824. 1830. 1836. 1842. 1848. 1854. 1860. 1866. 1872. 1878. 1884. 1890. 1896. 1902. 1908. 1914. 1920. 1926. 1932. 1938. 1944. 1950. 1956. 1962. 1968. 1974. 1980. 1986. 1992. 1998. 2004. 2010. 2016. 2022. 2028. 2034. 2040. 2046. 2052. 2058. 2064. 2070. 2076. 2082. 2088. 2094. 2100. 2106. 2112. 2118. 2124. 2130. 2136. 2142. 2148. 2154. 2160. 2166. 2172. 2178. 2184. 2190. 2196. 2202. 2208. 2214. 2220. 2226. 2232. 2238. 2244. 2250. 2256. 2262. 2268. 2274. 2280. 2286. 2292. 2298. 2304. 2310. 2316. 2322. 2328. 2334. 2340. 2346. 2352. 2358. 2364. 2370. 2376. 2382. 2388. 2394. 2400. 2406. 2412. 2418. 2424. 2430. 2436. 2442. 2448. 2454. 2460. 2466. 2472. 2478. 2484. 2490. 2496. 2502. 2508. 2514. 2520. 2526. 2532. 2538. 2544. 2550. 2556. 2562. 2568. 2574. 2580. 2586. 2592. 2598. 2604. 2610. 2616. 2622. 2628. 2634. 2640. 2646. 2652. 2658. 2664. 2670. 2676. 2682. 2688. 2694. 2700. 2706. 2712. 2718. 2724. 2730. 2736. 2742. 2748. 2754. 2760. 2766. 2772. 2778. 2784. 2790. 2796. 2802. 2808. 2814. 2820. 2826. 2832. 2838. 2844. 2850. 2856. 2862. 2868. 2874. 2880. 2886. 2892. 2898. 2904. 2910. 2916. 2922. 2928. 2934. 2940. 2946. 2952. 2958. 2964. 2970. 2976. 2982. 2988. 2994. 3000. 3006. 3012. 3018. 3024. 3030. 3036. 3042. 3048. 3054. 3060. 3066. 3072. 3078. 3084. 3090. 3096. 3102. 3108. 3114. 3120. 3126. 3132. 3138. 3144. 3150. 3156. 3162. 3168. 3174. 3180. 3186. 3192. 3198. 3204. 3210. 3216. 3222. 3228. 3234. 3240. 3246. 3252. 3258. 3264. 3270. 3276. 3282. 3288. 3294. 3300. 3306. 3312. 3318. 3324. 3330. 3336. 3342. 3348. 3354. 3360. 3366. 3372. 3378. 3384. 3390. 3396. 3402. 3408. 3414. 3420. 3426. 3432. 3438. 3444. 3450. 3456. 3462. 3468. 3474. 3480. 3486. 3492. 3498. 3504. 3510. 3516. 3522. 3528. 3534. 3540. 3546. 3552. 3558. 3564. 3570. 3576. 3582. 3588. 3594. 3600. 3606. 3612. 3618. 3624. 3630. 3636. 3642. 3648. 3654. 3660. 3666. 3672. 3678. 3684. 3690. 3696. 3702. 3708. 3714. 3720. 3726. 3732. 3738. 3744. 3750. 3756. 3762. 3768. 3774. 3780. 3786. 3792. 3798. 3804. 3810. 3816. 3822. 3828. 3834. 3840. 3846. 3852. 3858. 3864. 3870. 3876. 3882. 3888. 3894. 3900. 3906. 3912. 3918. 3924. 3930. 3936. 3942. 3948. 3954. 3960. 3966. 3972. 3978. 3984. 3990. 3996. 4002. 4008. 4014. 4020. 4026. 4032. 4038. 4044. 4050. 4056. 4062. 4068. 4074. 4080. 4086. 4092. 4098. 4104. 4110. 4116. 4122. 4128. 4134. 4140. 4146. 4152. 4158. 4164. 4170. 4176. 4182. 4188. 4194. 4200. 4206. 4212. 4218. 4224. 4230. 4236. 4242. 4248. 4254. 4260. 4266. 4272. 4278. 4284. 4290. 4296. 4302. 4308. 4314. 4320. 4326. 4332. 4338. 4344. 4350. 4356. 4362. 4368. 4374. 4380. 4386. 4392. 4398. 4404. 4410. 4416. 4422. 4428. 4434. 4440. 4446. 4452. 4458. 4464. 4470. 4476. 4482. 4488. 4494. 4500. 4506. 4512. 4518. 4524. 4530. 4536. 4542. 4548. 4554. 4560. 4566. 4572. 4578. 4584. 4590. 4596. 4602. 4608. 4614. 4620. 4626. 4632. 4638. 4644. 4650. 4656. 4662. 4668. 4674. 4680. 4686. 4692. 4698. 4704. 4710. 4716. 4722. 4728. 4734. 4740. 4746. 4752. 4758. 4764. 4770. 4776. 4782. 4788. 4794. 4800. 4806. 4812. 4818. 4824. 4830. 4836. 4842. 4848. 4854. 4860. 4866. 4872. 4878. 4884. 4890. 4896. 4902. 4908. 4914. 4920. 4926. 4932. 4938. 4944. 4950. 4956. 4962. 4968. 4974. 4980. 4986. 4992. 4998. 5004. 5010. 5016. 5022. 5028. 5034. 5040. 5046. 5052. 5058. 5064. 5070. 5076. 5082. 5088. 5094. 5100. 5106. 5112. 5118. 5124. 5130. 5136. 5142. 5148. 5154. 5160. 5166. 5172. 5178. 5184. 5190. 5196. 5202. 5208. 5214. 5220. 5226. 5232. 5238. 5244. 5250. 5256. 5262. 5268. 5274. 5280. 5286. 5292. 5298. 5304. 5310. 5316. 5322. 5328. 5334. 5340. 5346. 5352. 5358. 5364. 5370. 5376. 5382. 5388. 5394. 5400. 5406. 5412. 5418. 5424. 5430. 5436. 5442. 5448. 5454. 5460. 5466. 5472. 5478. 5484. 5490. 5496. 5502. 5508. 5514. 5520. 5526. 5532. 5538. 5544. 5550. 5556. 5562. 5568. 5574. 5580. 5586. 5592. 5598. 5604. 5610. 5616. 5622. 5628. 5634. 5640. 5646. 5652. 5658. 5664. 5670. 5676. 5682. 5688. 5694. 5700. 5706. 5712. 5718. 5724. 5730. 5736. 5742. 5748. 5754. 5760. 5766. 5772. 5778. 5784. 5790. 5796. 5802. 5808. 5814. 5820. 5826. 5832. 5838. 5844. 5850. 5856. 5862. 5868. 5874. 5880. 5886. 5892. 5898. 5904. 5910. 5916. 5922. 5928. 5934. 5940. 5946. 5952. 5958. 5964. 5970. 5976. 5982. 5988. 5994. 6000. 6006. 6012. 6018. 6024. 6030. 6036. 6042. 6048. 6054. 6060. 6066. 6072. 6078. 6084. 6090. 6096. 6102. 6108. 6114. 6120. 6126. 6132. 6138. 6144. 6150. 6156. 6162. 6168. 6174. 6180. 6186. 6192. 6198. 6204. 6210. 6216. 6222. 6228. 6234. 6240. 6246. 6252. 6258. 6264. 6270. 6276. 6282. 6288. 6294. 6300. 6306. 6312. 6318. 6324. 6330. 6336. 6342. 6348. 6354. 6360. 6366. 6372. 6378. 6384. 6390. 6396. 6402. 6408. 6414. 6420. 6426. 6432. 6438. 6444. 6450. 6456. 6462. 6468. 6474. 6480. 6486. 6492. 6498. 6504. 6510. 6516. 6522. 6528. 6534. 6540. 6546. 6552. 6558. 6564. 6570. 6576. 6582. 6588. 6594. 6600. 6606. 6612. 6618. 6624. 6630. 6636. 6642. 6648. 6654. 6660. 6666. 6672. 6678. 6684. 6690. 6696. 6702. 6708. 6714. 6720. 6726. 6732. 6738. 6744. 6750. 6756. 6762. 6768. 6774. 6780. 6786. 6792. 6798. 6804. 6810. 6816. 6822. 6828. 6834. 6840. 6846. 6852. 6858. 6864. 6870. 6876. 6882. 6888. 6894. 6900. 6906. 6912. 6918. 6924. 6930. 6936. 6942. 6948. 6954. 6960. 6966. 6972. 6978. 6984. 6990. 6996. 7002. 7008. 7014. 7020. 7026. 7032. 7038. 7044. 7050. 7056. 7062. 7068. 7074. 7080. 7086. 7092. 7098. 7104. 7110. 7116. 7122. 7128. 7134. 7140. 7146. 7152. 7158. 7164. 7170. 7176. 7182. 7188. 7194. 7200. 7206. 7212. 7218. 7224. 7230. 7236. 7242. 7248. 7254. 7260. 7266. 7272. 7278. 7284. 7290. 7296. 7302. 7308. 7314. 7320. 7326. 7332. 7338. 7344. 7350. 7356. 7362. 7368. 7374. 7380. 7386. 7392. 7398. 7404. 7410. 7416. 7422. 7428. 7434. 7440. 7446. 7452. 7458. 7464. 7470. 7476. 7482. 7488. 7494. 7500. 7506. 7512. 7518. 7524. 7530. 7536. 7542. 7548. 7554. 7560. 7566. 7572. 7578. 7584. 7590. 7596. 7602. 7608. 7614. 7620. 7626. 7632. 7638. 7644. 7650. 7656. 7662. 7668. 7674. 7680. 7686. 7692. 7698. 7704. 7710. 7716. 7722. 7728. 7734. 7740. 7746. 7752. 7758. 7764. 7770. 7776. 7782. 7788. 7794. 7800. 7806. 7812. 7818. 7824. 7830. 7836. 7842. 7848. 7854. 7860. 7866. 7872. 7878. 7884. 7890. 7896. 7902. 7908. 7914. 7920. 7926. 7932. 7938. 7944. 7950. 7956. 7962. 7968. 7974. 7980. 7986. 7992. 7998. 8004. 8010. 8016. 8022. 8028. 8034. 8040. 8046. 8052. 8058. 8064. 8070. 8076. 8082. 8088. 8094. 8100. 8106. 8112. 8118. 8124. 8130. 8136. 8142. 8148. 8154. 8160. 8166. 8172. 8178. 8184. 8190. 8196. 8202. 8208. 8214. 8220. 8226. 8232. 8238. 8244. 8250. 8256. 8262. 8268. 8274. 8280. 8286. 8292. 8298. 8304. 8310. 8316. 8322. 8328. 8334. 8340. 8346. 8352. 8358. 8364. 8370. 8376. 8382. 8388. 8394. 8400. 8406. 8412. 8418. 8424. 8430. 8436. 8442. 8448. 8454. 8460. 8466. 8472. 8478. 8484. 8490. 8496. 8502. 8508. 8514. 8520. 8526. 8532. 8538. 8544. 8550. 8556. 8562. 8568. 8574. 8580. 8586. 8592. 8598. 8604. 8610. 8616. 8622. 8628. 8634. 8640. 8646. 8652. 8658. 8664. 8670. 8676. 8682. 8688. 8694. 8700. 8706. 8712. 8718. 8724. 8730. 8736. 8742. 8748. 8754. 8760. 8766. 8772. 8778. 8784. 8790. 8796. 8802. 8808. 8814. 8820. 8826. 8832. 8838. 8844. 8850. 8856. 8862. 8868. 8874. 8880. 8886. 8892. 8898. 8904. 8910. 8916. 8922. 8928. 8934. 8940. 8946. 8952. 8958. 8964. 8970. 8976. 8982. 8988. 8994. 9000. 9006. 9012. 9018. 9024. 9030. 9036. 9042. 9048. 9054. 9060. 9066. 9072. 9078. 9084. 9090. 9096. 9102. 9108. 9114. 9120. 9126. 9132. 9138. 9144. 9150. 9156. 9162. 9168. 9174. 9180. 9186. 9192. 9198. 9204. 9210. 9216. 9222. 9228. 9234. 9240. 9246. 9252. 9258. 9264. 9270. 9276. 9282. 9288. 9294. 9300. 9306. 9312. 9318. 9324. 9330. 9336. 9342. 9348. 9354. 9360. 9366. 9372. 9378. 9384. 9390. 9396. 9402. 9408. 9414. 9420. 9426. 9432. 9438. 9444. 9450. 9456. 9462. 9468. 9474. 9480. 9486. 9492. 9498. 9504. 9510. 9516. 9522. 9528. 9534. 9540. 9546. 9552. 9558. 9564. 9570. 9576. 9582. 9588. 9594. 9600. 9606. 9612. 9618. 9624. 9630. 9636. 9642. 9648. 9654. 9660. 9666. 9672. 9678. 9684. 9690. 9696. 9702. 9708. 9714. 9720. 9726. 9732. 9738. 9744. 9750. 9756. 9762. 9768. 9774. 9780. 9786. 9792. 9798. 9804. 9810. 9816. 9822. 9828. 9834. 9840. 9846. 9852. 9858. 9864. 9870. 9876. 9882. 9888. 9894. 9900. 9906. 9912. 9918. 9924. 9930. 9936. 9942. 9948. 9954. 9960. 9966. 9972. 9978. 9984. 9990. 9996. 10002. 10008. 10014. 10020. 10026. 10032. 10038. 10044. 10050. 10056. 10062. 10068. 10074. 10080. 10086. 10092. 10098. 10104. 10110. 10116. 10122. 10128. 10134. 10140. 10146. 10152. 10158. 10164. 10170. 10176. 10182. 10188. 10194. 10200. 10206. 10212. 10218. 10224. 10230. 10236. 10242. 10248. 10254. 10260. 10266. 10272. 10278. 10284. 10290. 10296. 10302. 10308. 10314. 10320. 10326. 10332. 10338. 10344. 10350. 10356. 10362. 10368. 10374. 10380. 10386. 10392. 10398. 10404. 10410. 10416. 10422. 10428. 10434. 10440. 10446. 10452. 10458. 10464. 10470. 10476. 10482. 10488. 10494. 10500. 10506. 10512. 10518. 10524. 10530. 10536. 10542. 10548. 10554. 10560. 10566. 10572. 10578. 10584. 10590. 10596. 10602. 10608. 10614. 10620. 10626. 10632. 10638. 10644. 10650. 10656. 10662. 10668. 10674. 10680. 10686. 10692. 10698. 10704. 10710. 10716. 10722. 10728. 10734. 10740. 10746. 10752. 10758. 10764. 10770. 10776. 10782. 10788. 10794. 10800. 10806. 10812. 10818. 10824. 10830. 10836. 10842. 10848. 10854. 10860. 10866. 10872. 10878. 10884. 10890. 10896. 10902. 10908. 10914. 10920. 10926. 10932. 10938. 10944. 10950. 10956. 10962. 10968. 10974. 10980. 10986. 10992. 10998. 11004. 11010. 11016. 11022. 11028. 11034. 11040. 11046. 11052. 11058. 11064. 11070. 11076. 11082. 11088. 11094. 11100. 11106. 11112. 11118. 11124. 11130. 11136. 11142. 11148. 11154. 11160. 11166. 11172. 11178. 11184. 11190. 11196. 11202. 11208. 11214. 11220. 11226. 11232. 11238. 11244. 11250. 11256. 11262. 11268. 11274. 11280. 11286. 11292. 11298. 11304. 11310. 11316. 11322. 11328. 11334. 11340. 11346. 11352. 11358. 11364. 11370. 11376. 11382. 11388. 11394. 11400. 11406. 11412. 11418. 11424. 11430. 11436. 11442. 11448. 11454. 11460. 11466. 11472. 11478. 11484. 11490. 11496. 11502. 11508. 11514. 11520. 11526. 11532. 11538. 11544. 11550. 11556. 11562. 11568. 11574. 11580. 11586. 11592. 11598. 11604. 11610. 11616. 11622. 11628. 11634. 11640. 11646. 11652. 11658. 11664. 11670. 11676. 11682. 11688. 11694. 11700. 11706. 11712. 11718. 11724. 11730. 11736. 11742. 11748. 11754. 11760. 11766. 11772. 11778. 11784. 11790. 11796. 11802. 11808. 11814. 11820. 11826. 11832. 11838. 11844. 11850. 11856. 11862. 11868. 11874. 11880. 11886. 11892. 11898. 11904. 11910. 11916. 11922. 11928. 11934. 11940. 11946. 11952. 11958. 11964. 11970. 11976. 11982. 11988. 11994. 12000. 12006.

REPORT NOW OUT

DISCHARGE RATE IS 16-Ohm Resistor

03.00 05.10 05.30 05.40 05.50 06.00 06.10 06.20 06.30 06.40 06.50 07.00 07.10 07.20 07.30 07.40 07.50 08.00 08.10 08.20 08.30 08.40 08.50 09.00 09.10 09.20 09.30 09.40 09.50 10.00 10.10 10.20 10.30 10.40 10.50 11.00 11.10 11.20 11.30 11.40 11.50 12.00 12.10 12.20 12.30 12.40 12.50 13.00 13.10 13.20 13.30 13.40 13.50 14.00 14.10 14.20 14.30 14.40 14.50 15.00 15.10 15.20 15.30 15.40 15.50 16.00 16.10 16.20 16.30 16.40 16.50 17.00 17.10 17.20 17.30 17.40 17.50 18.00 18.10 18.20 18.30 18.40 18.50 19.00 19.10 19.20 19.30 19.40 19.50 20.00 20.10 20.20 20.30 20.40 20.50 21.00 21.10 21.20 21.30 21.40 21.50 22.00 22.10 22.20 22.30 22.40 22.50 23.00 23.10 23.20 23.30 23.40 23.50 24.00 24.10 24.20 24.30 24.40 24.50 25.00 25.10 25.20 25.30 25.40 25.50 26.00 26.10 26.20 26.30 26.40 26.50 27.00 27.10 27.20 27.30 27.40 27.50 28.00 28.10 28.20 28.30 28.40 28.50 29.00 29.10 29.20 29.30 29.40 29.50 30.00 30.10 30.20 30.30 30.40 30.50 31.00 31.10 31.20 31.30 31.40 31.50 32.00 32.10 32.20 32.30 32.40 32.50 33.00 33.10 33.20 33.30 33.40 33.50 34.00 34.10 34.20 34.30 34.40 34.50 35.00 35.10 35.20 35.30 35.40 35.50 36.00 36.10 36.20 36.30 36.40 36.50 37.00 37.10 37.20 37.30 37.40 37.50 38.00 38.10 38.20 38.30 38.40 38.50 39.00 39.10 39.20 39.30 39.40 39.50 40.00 40.10 40.20 40.30 40.40 40.50 41.00 41.10 41.20 41.30 41.40 41.50 42.00 42.10 42.20 42.30 42.40 42.50 43.00 43.10 43.20 43.30 43.40 43.50 44.00 44.10 44.20 44.30 44.40 44.50 45.00 45.10 45.20 45.30 45.40 45.50 46.00 46.10 46.20 46.30 46.40 46.50 47.00 47.10 47.20 47.30 47.40 47.50 48.00 48.10 48.20 48.30 48.40 48.50 49.00 49.10 49.20 49.30 49.40 49.50 50.00 50.10 50.20 50.30 50.40 50.50 51.00 51.10 51.20 51.30 51.40 51.50 52.00 52.10 52.20 52.30 52.40 52.50 53.00 53.10 53.20 53.30 53.40 53.50 54.00 54.10 54.20 54.30 54.40 54.50 55.00 55.10 55.20 55.30 55.40 55.50 56.00 56.10 56.20 56.30 56.40 56.50 57.00 57.10 57.20 57.30 57.40 57.50 58.00 58.10 58.20 58.30 58.40 58.50 59.00 59.10 59.20 59.30 59.40 59.50 60.00 60.10 60.20 60.30 60.40 60.50 61.00 61.10 61.20 61.30 61.40 61.50 62.00 62.10 62.20 62.30 62.40 62.50 63.00 63.10 63.20 63.30 63.40 63.50 64.00 64.10 64.20 64.30 64.40 64.50 65.00 65.10 65.20 65.30 65.40 65.50 66.00 66.10 66.20 66.30 66.40 66.50 67.00 67.10 67.20 67.30 67.40 67.50 68.00 68.10 68.20 68.30 68.40 68.50 69.00 69.10 69.20 69.30 69.40 69.50 70.00 70.10 70.20 70.30 70.40 70.50 71.00 71.10 71.20 71.30 71.40 71.50 72.00 72.10 72.20 72.30 72.40 72.50 73.00 73.10 73.20 73.30 73.40 73.50 74.00 74.10 74.20 74.30 74.40 74.50 75.00 75.10 75.20 75.30 75.40 75.50 76.00 76.10 76.20 76.30 76.40 76.50 77.00 77.10 77.20 77.30 77.40 77.50 78.00 78.10 78.20 78.30 78.40 78.50 79.00 79.10 79.20 79.30 79.40 79.50 80.00 80.10 80.20 80.30 80.40 80.50 81.00 81.10 81.20 81.30 81.40 81.50 82.00 82.10 82.20 82.30 82.40 82.50 83.00 83.10 83.20 83.30 83.40 83.50 84.00 84.10 84.20 84.30 84.40 84.50 85.00 85.10 85.20 85.30 85.40 85.50 86.00 86.10 86.20 86.30 86.40 86.50 87.00 87.10 87.20 87.30 87.40 87.50 88.00 88.10 88.20 88.30 88.40 88.50 89.00 89.10 89.20 89.30 89.40 89.50 90.00 90.10 90.20 90.30 90.40 90.50 91.00 91.10 91.20 91.30 91.40 91.50 92.00 92.10 92.20 92.30 92.40 92.50 93.00 93.10 93.20 93.30 93.40 93.50 94.00 94.10 94.20 94.30 94.40 94.50 95.00 95.10 95.20 95.30 95.40 95.50 96.00 96.10 96.20 96.30 96.40 96.50 97.00 97.10 97.20 97.30 97.40 97.50 98.00 98.10 98.20 98.30 98.40 98.50 99.00 99.10 99.20 99.30 99.40 99.50 100.00 100.10 100.20 100.30 100.40 100.50 101.00 101.10 101.20 101.30 101.40 101.50 102.00 102.10 102.20 102.30 102.40 102.50 103.00 103.10 103.20 103.30 103.40 103.50 104.00 104.10 104.20 104.30 104.40 104.50 105.00 105.10 105.20 105.30 105.40 105.50 106.00 106.10 106.20 106.30 106.40 106.50 107.00 107.10 107.20 107.30 107.40 107.50 108.00 108.10 108.20 108.30 108.40 108.50 109.00 109.10 109.20 109.30 109.40 109.50 110.00 110.10 110.20 110.30 110.40 110.50 111.00 111.10 111.20 111.30 111.40 111.50 112.00 112.10 112.20 112.30 112.40 112.50 113.00 113.10 113.20 113.30 113.40 113.50 114.00 114.10 114.20 114.30 114.40 114.50 115.00 115.10 115.20 115.30 115.40 115.50 116.00 1



CELLS 5713
T-1 0307Z
TIME IN MONTHS
2-A 3-A 4-A 5-A

FIGURE 365

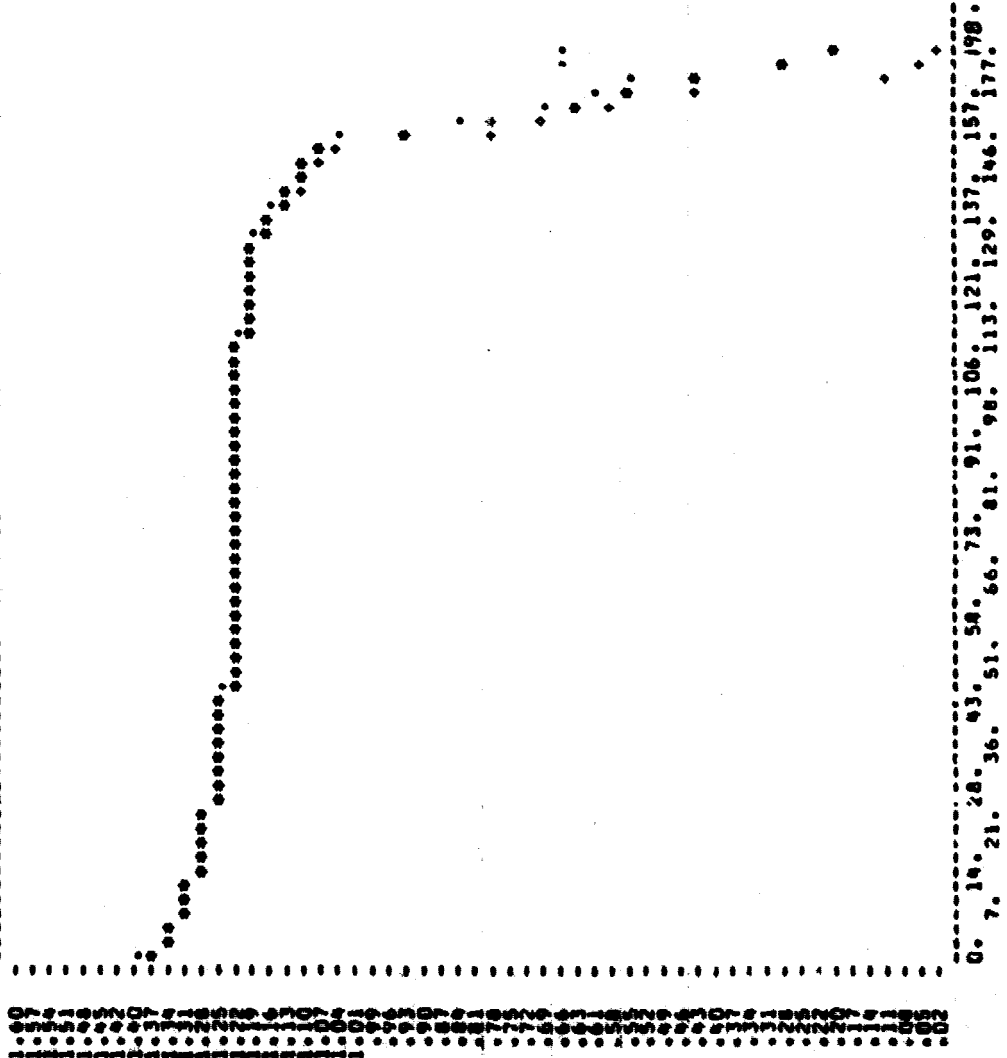
WPEC/C 83-120A

AMPERE HOUR OUT

PACK NUMBER IS 2328
RECORD NUMBER IS 03
CYCLE NUMBER IS 380
DISCHARGE RATE IS 18-Ohm Resistor

0. 5.99 12.02 18.04 24.06 29.99 37.03 43.18 48.93 55.09 61.04 64.74
3.00 8.98 15.97 20.98 27.00 33.02 40.10 45.86 52.21 58.16 63.99

ORIGINAL PAGE IS
OF POOR QUALITY



CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 366

of the 1980s, the 1990s, and the 2000s. The 1980s were characterized by a focus on the environment and social issues, while the 1990s saw a shift towards economic and technological progress. The 2000s, however, were marked by a renewed interest in the environment and social issues, reflecting a growing awareness of the impact of human activities on the planet and society.

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CHARGE VOLTAGE
DISCHARGE VOLTAGE
CHARGE VOLTAGE
DISCHARGE VOLTAGE

-MOOTHS-

SHADOW-3

2-400W-2

SHADGW-1

051501
13762

1.509

1.450

120-1

1-386

1-345

●

Ref:

•

1-183

001-1

600-3

ASD-1

2

55

•

32

1

1

333

100

100

FIGURE 367

KEY
1 AMO
1 AMO-TOTAL

DEPTH DISCHARGE 50
TEMPERATURE 40
AMPERE RATE 40
SERIAL 101,193,194,195,196
PROJECT - GENERAL ELECTRIC
FMS

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 2328

